CONTRIBUTORS TO VOLUME I.

ABBE, ROBERT, M.D.

BECK, JOSEPH C., M.D., F.A.C.S.

BROWN, GEORGE VAN INGEN, A.B., D.D.S., M.D., F.A.C.S.

CRILE, GEORGE W., A.M., M.D., F.A.C.S., F.R.C.S. (Hon.)

CUSHING, HARVEY, M.D., Sc.D., F.R.C.S.

GIBBON, JOHN H., M.D.

JACKSON, CHEVALIER, M.D.

JONAS, A. F., M.D.

KAHLKE, CHARLES EDWIN, B.S., M.D., F.A.C.S.

KANAVEL, ALLEN B., M.D.

NUZUM, JOHN W., S.B., M.D.

OCHSNER, ALBERT J., M.D., LL.D., F.A.C.S., F.R.M.S.

PERCY, NELSON MORTIMER, M.D., F.A.C.S.

SCHMIDT, EDWIN R., B.A., M.D.

SCHMITZ, HENRY, A.M., M.D., F.A.C.S.

SHAMBAUGH, GEORGE E., M.D.

STANTON, E. MacD., B.Sc., M.D., F.A.C.S.

TINKER, MARTIN B., M.D.

SURGICAL

DIAGNOSIS AND TREATMENT

BY AMERICAN AUTHORS

EDITED BY

ALBERT J. OCHSNER, M.D., LL.D., F.A.C.S., F.R.M.S.

PROFESSOR OF SURGERY IN THE MEDICAL DEPARTMENT OF THE UNIVERSITY OF ILLINOIS;
SURGEON-IN-CHIEF TO THE AUGUSTANA AND ST. MARY'S HOSPITALS,
CHICAGO, ILL.

ILLUSTRATED WITH 562 ENGRAVINGS AND
15 COLORED PLATES

VOLUME I

LEA & FEBIGER
PHILADELPHIA AND NEW YORK

PREFACE.

THE professional careers of the present leaders in surgery represent a period of advance in methods of diagnosis and treatment unequalled by the progress of many previous centuries. The atmosphere of spiritual and material progress in which they live enables these men to abandon precedent and accept new ideas. To them must be credited the introduction, the development and the adoption of many innovations far beyond the imagination of their predecessors. Their unselfish devotion deserves and receives world-wide recognition. Therefore, it has seemed eminently proper to collect and, in their own language, to record in these volumes the conclusions of this group of contemporary workers who have so splendidly utilized their unusual opportunities to enrich surgical knowledge.

At the present time it is deemed especially desirable to publish a comprehensive work emphasizing both surgical diagnosis and treatment; because, on the part of the surgeon, there have lately been signs of relaxation on the side of diagnosis. To neglect the application of any resource in this, its most difficult department, would soon lose for surgery the enviable position won for it by the tireless efforts of a generation.

This work in every sense reflects the current practice and thought of the most intensely active surgeons of this continent. Its chapters endeavor to tell the *why* and *how* in the solution of each surgical problem, and to bring the reader in touch with the actual experience, reasoning and practical methods of men eminent in all parts of the country. Each one describes intimately his methods of diagnosis, his plans for treatment before and after operation and gives his judgment regarding them.

The reader may feel assured that he will find nothing here that smacks of what is copied from text-books; but only fresh material that represents the living work of today done by those whose powers of observation make their conclusions worthy of confidence. So far as possible, duplication has been avoided on the one hand, and on the other an attempt has been made to cover the entire field of general surgery. Specialties have been invaded only so far as the general surgeon is justified in going when special skill is unavailable.

In greater part the articles have been prepared during the strenuous years of the world war, which rendered the labor more arduous for contributors and publishers alike, but it has added immeasurably to the value of the work. With the exception of a few whose duties as teachers held them at their posts, all of the contributors were in the medical service of the Allied armies, and the material relating to war surgery has been written from the abundance of their recent experience.

The editor desires to express his appreciation of the courtesies extended to him by all contributors as well as by the publishers. He especially wishes gratefully to record his obligation for help received from his assistants, Drs. Dennis W. Crile, Frank H. Doubler, O. E. Nadeau, John W. Nuzum and Erwin R. Schmidt.

A. J. O.

CHICAGO, 1920.

CONTRIBUTORS.

ROBERT ABBE, M.D.,
Senior Surgeon at St. Luke's Hospital; Consulting Surgeon to the Roosevelt, the Woman's, the Hospital for Ruptured and Crippled and the Babies' Hospitals, New York City; Associate Fellow of the College of Physicians of Philadelphia, etc.

JOSEPH C. BECK, M.D., F.A.C.S.,
Associate Professor of Otolaryngology in the University of Illinois, Chicago, Ill.; Attending Otolaryngologist to the Cook County Hospital and the North Chicago Hospital, Chicago, Ill.

GEORGE VAN INGEN BROWN, A.B., D.D.S., M.D., F.A.C.S.,
Lieutenant-Colonel, Medical Reserve Corps, U. S. Army; Surgeon, U. S. Public Health Service, and Consultant in Plastic Surgery, U. S. Public Health Service at Milwaukee; Plastic and Oral Surgeon to St. Mary's Hospital and to the Children's Free Hospital and Columbia Hospital, Milwaukee, Wis.; Fellow of the American Medical Association; Member of the National Dental Association; Chairman of the Section on Oral Surgery of the Fourth International Dental Congress, etc.; formerly in charge of the Sub-section of Plastic and Oral Surgery of the Head Surgery Division of the Office of the Surgeon-General; Chief of the Maxillofacial Service at Walter Reed Hospital, Takoma Park, Washington, D. C.

GEORGE W. CRILE, A.M., M.D., F.A.C.S., F.R.C.S. (Hon.),
Professor of Surgery in the Western Reserve University, Cleveland, Ohio; Visiting Surgeon to the Lakeside Hospital, Cleveland, Ohio.

HARVEY CUSHING, M.D., ScD., F.R.C.S.,
Professor of Surgery in the Harvard University; Surgeon-in-Chief to the Peter Bent Brigham Hospital, Boston, Mass.

JOHN H. GIBBON, M.D.,
Professor of Surgery in the Jefferson Medical College, Philadelphia; Surgeon to the Pennsylvania and Jefferson Hospitals, Philadelphia, and Consulting Surgeon to the Bryn Mawr Hospital, Bryn Mawr, Pa.; Late Colonel in the Medical Corps of the United States Army.

CHEVALIER JACKSON, M.D.,
Professor of Laryngology in the Jefferson Medical College, Philadelphia.

A. F. JONAS, M.D.,
Head of Surgery in the Medical Department of the State University; Surgeon at the Nebraska State University Hospital, the Nebraska Methodist Episcopal Hospital, and the Wise Memorial Hospital, Omaha, Neb.; Chief Surgeon of the Union Pacific Railroad, Omaha, Neb.

CHARLES EDWIN KAHLKE, B.S., M.D., F.A.C.S.,
Chicago, Ill.

ALLEN B. KANAVEL, M.D.,
Professor of Surgery in the Northwestern University Medical School; Attending Surgeon at the Wesley Memorial and Cook County Hospitals, Chicago, Ill.

JOHN W. NUZUM, S.B., M.D.,
Associate in Anatomy and Pathology in the University of Illinois, College of Medicine, Chicago; Chief Surgical Assistant to Drs. A. J. Ochsner and Nelson Percy at Augustana Hospital, Chicago; formerly Director of the Laboratories in the Cook County Hospital, Chicago, Ill.

ALBERT J. OCHSNER, M.D., LL.D., F.A.C.S., F.R.M.S.,
Professor of Surgery in the Medical Department of the University of Illinois; Surgeon-in-Chief to the Augustana and St. Mary's Hospitals, Chicago, Ill.

NELSON MORTIMER PERCY, M.D., F.A.C.S.,
Associate Professor of Clinical Surgery in the University of Illinois College of Medicine, Chicago; Attending Surgeon to the Augustana and St. Mary's Hospitals, Chicago, Ill.; Fellow of the American Surgical Association.

EDWIN R. SCHMIDT, B.A., M.D.,
Chief of Resident Staff of the Augustana Hospital, Chicago, Ill.; Captain, Medical Corps, U. S. Army.

HENRY SCHMITZ, A.M., M.D., F.A.C.S.,
Professor and Head of the Department of Gynecology in the Loyola University School of Medicine; Attending Surgeon at St. Mary's of Nazareth Hospital; Attending Gynecologist at the Cook County Hospital and the Frances E. Willard National Temperance Hospital, Chicago, Ill.

GEORGE E. SHAMBAUGH, M.D.,
Professor of Otology and Laryngology in the Rush Medical College; Otologist to the Presbyterian Hospital, Chicago, Ill.

E. MacD. STANTON, B.Sc., M.D., F.A.C.S.,
Surgeon to the Ellis Hospital, Schenectady, New York.

MARTIN B. TINKER, M.D.,
Lieut.-Colonel in the Medical Reserve Corps of the United States Army; Chief of Surgical Service at the U. S. General Hospital No. 26, Fort Des Moines, Iowa; Formerly Assistant Professor of Surgery at Cornell University, Ithaca, New York.

CONTENTS.

SURGICAL PROGNOSIS.

By E. MacD. STANTON, M.D., F.A.C.S.

In surgery the relation between cause and effect, the operation and its result, is usually so definite that the subject of prognosis assumes a position of far greater relative importance than in most other branches of medicine. A thorough knowledge of surgical prognosis is the most essential single requisite for a sound surgical judgment, and, no matter how great the surgeon's diagnostic ability or how excellent his operative technic, his ultimate standing as a surgeon will be determined very largely by the standard of surgical judgment which characterizes his work.

When we attempt to deal with the general aspects of surgical prognosis it is well for us to bear in mind that there are two distinct mental processes by which the surgeon may arrive at the approximate prognosis of the individual case.

First, he may ascertain the results previously obtained in similar cases, beginning with the average results obtained in all those individuals who have suffered from the same disease and proceeding ultimately to the results obtained in smaller groups of cases more nearly approaching in their various details the character of the case under consideration. This first or comparative method necessitates an intimate knowledge of the statistical data having to do with the prognosis of each separate disease. The specific portions of our knowledge concerning this phase of prognosis are far too complex in their detail to be encompassed in the limits of this chapter.

The second method depends chiefly upon a careful study of the individual patient with special reference to each one of those factors which may be ascertained to have a distinct bearing on the outcome of the case. These factors, which have to do principally with the general condition of the patient and the dangers and complications incident to all surgical diseases and operations, can be discussed to advantage in a chapter devoted expressly to this purpose.

STATISTICS IN PROGNOSIS.

Because statistics play such an important part in all discussions pertaining to the subject, it may be well to emphasize several facts concerning the value of and the limitations of statistics in prognosis. Statistics properly handled are essential for determining many of the most important truths concerning prognosis. That they are not always properly interpreted, and that both medicine and surgery have been abundantly burdened with figures of doubtful or even negative value means only that due care should be used in drawing conclusions from this kind of data. The man with a thorough knowledge of the subject at hand and a fair sense of mathematical proportion usually finds little difficulty in ascertaining the important points demonstrated by the statistical data presented.

The most common error arising from the use of medical as well as other statistics comes from a failure to recognize the fact that generalities, no matter how true they may be in themselves, are not meant to be applied directly to specific instances. For example, statistics collected from all over the world show that, taken as a whole, the operative mortality in acute appendicitis has borne a quite definite relationship to the day of the disease on which the patient has been operated. That these figures do show certain great truths concerning the mortality of acute appendicitis is proved by the fact that the results are essentially uniform for large groups of cases compiled from clinics in no way connected with one another. Yet because there has been an average mortality of say 8 per cent. for patients subjected to operation during the third day of the acute attack, it does not mean that this figure represents the true prognosis in the majority of individual third-day appendix cases. As a matter of fact a perfectly accurate individual prognosis under the circumstances existing at the time the patients were operated upon would have been wholly favorable in 92 per cent. of the cases, and entirely unfavorable in 8 per cent. The absurdity of predicting one chance in twelve of death for each individual third-day appendix case because that may have been the average for cases operated during the third day of the attack is self evident.

It is a fact to be regretted that much of the available data purporting to show the results obtained in the many special fields of surgery has emanated from the clinics of those who have devoted particular attention and skill to the special line of work, the results of which, they have reported. Just in so far as these reports represent the exceptional rather than the average results they are liable to be misleading. Such statistics should be interpreted as representing what can be accomplished under exceptional circumstances rather than as a fair estimate of the results to be expected under ordinary conditions. The true prognosis and the permanent standing of a surgical procedure are determined not by the exceptional results which may be obtained by some master in a particular line of work, but by the average results which are obtained by other surgeons using the same methods.

The introduction of a standard case-record system for hospitals complying with the standardization requirements of the American College of Surgeons has been a notable advance which is bound to result in the accumulation of much needed data pertaining to the subject of surgical prognosis. The summary card recommended by the

College is admirably adopted to the purpose of collecting end-result data.

Data as to end-results is best attained by means of letters sent to the patients at regular intervals following the operation. In the case of general hospitals treating large numbers of charity patients the proportion of answers received to these letters is often disappointing. On the other hand in private practice we have for a number of years received more than 90 per cent. of replies to the following letter:

SCHENECTADY, N. Y.

"It is now just a year since your operation, and as I am anxious to keep track of the results obtained in all cases operated by me, I will appreciate the favor if you will fill out the answers to the following questions and return this letter in the enclosed stamped envelope.

After the operation were you cured of the trouble from which you sought relief?
....

If cured, how long after the operation was it before you recovered your strength?
....

If not entirely cured, what symptoms referable to the old condition still persist?
....

Were there any ill effects referable to the operation itself?........................

If so describe briefly what they were..

Please note any other points of interest concerning the results of your operation not covered by the above questions..

If you are not certain concerning the answers to the above questions you can call on your family physician for advice or you can telephone me or call at my office at any time during office hours.

Very sincerely,"

The system introduced by the American College of Surgeons is resulting in the collection of an enormous amount of data pertaining to the late results following operations. However my own end-result studies, carried out over a period of thirteen years, have convinced me that the chief reason for our present-day lack of end-result knowledge is not so much the lack of data as that surgeons have not as yet devised a uniform and satisfactory system for reporting the data which they have been able to collect. Surgical literature is full of communications dealing in a general way with the subject of end-results, in which it is evident that the author is in possession of considerable data which he has finally despaired of presenting in other than the most general terms.

Some time ago I found that I had several thousand histories with end-result records extending over fairly adequate periods of time, but that whereas these records had been collected with, let us say, one unit of energy on my part, when I came to study any one group of cases it took several units of time and energy to put the data into form suitable for study and comparison. In some groups it was impossible to classify the results according to the usually attempted standards. Also, I found that no two surgeons adopted the same standards in reporting their cases, so that it was impossible to compare small groups from different sources or to combine them into larger series of greater statistical value.

SURGEON'S CARD [Size, 5 x 8 inches]

Date of Opt'n Aug. 1, 1919.

Name Smith, John Hosp. No. 1022 Ward 28

Came for relief of Abd. pain, pyrexia and vomiting of 36 hours' duration.

Preop. Diag. Acute Appendicitis. Anesthet. Gas and Ether.

Opt'n—Important Points General condition good.

Appendix retrocecal - gangrenous - ounce of thick pus. Appendectomy and drainage.

Postoper. Diag. Acute Appendicitis - gangrenous with abscess.

Compl. of Convales. None. *[This means that there was no sepsis, bronchitis, cystitis, phlebitis, abscess formation or any other complication.]*

Dictated by

E. M. White, M.D.

After the operation the card goes with the temperature chart to the patient's bedside, and at his discharge the Complication item is filled out and O. K'd by the surgeon. The card is then given to the Librarian, by whom the data on it are neatly transferred to a permanent End-result Card, which is filed alphabetically. Cases which are not operated on have a similar card made out by their medical attendant.

END-RESULT CARD [Size, 5 x 8 inches]

	Date of Adm.	Date of Op.	Date of Discharge	Re-entry
Name Smith, John Hosp. No. 1022 Age 28 M.W.S.				
Addr. of Pt. 21 Charles St., Newton, Mass.	Aug. 1, 1919.	Aug. 1, 1919.	Aug. 17, 1919.	

Addr. of Pt's Phys. Dr. Geo. R. Brown, 36 Oak Street, Newton, Mass.

Perm. Addr. of Fr'nd Chas. H. Wright, 47 Chestnut St., Watertown, Vt.

Preop. Diag. Acute Appendicitis.

Post-op. Diag. Acute Appendicitis - gangrenous - with abscess.

Came for relief of Abdominal pain, pyrexia and vomiting of 36 hours' duration.

Optr. Dr. E. M. White

Anes. Gas and Ether

Opt'n. Impor. Pts. General condition good. Appendix retrocecal - gangrenous - abscess - ounce of thick pus. Appendectomy. Drainage.

Compl. of Convales. None.

Aut. No.

[The spaces are purposely made small so that only the essential facts would be put in them.]

*[To be marked **X** if patient returns and has another card]*

SUMMARY CARD

Case No.

Name | Address | Dr.

Final diagnosis	Age Adm. date Dis. date S. M. W. yrs Op. date
	Treatment: important points
Working diagnosis	
Physician referring patient	
Address	
Responsible relative or friend	
Address	Complications
Came for relief of	
	Pathological report
	Condition on discharge
Anesthetic and anesthetist	

(Reverse of Summary Card)

FOLLOW-UP RECORD

Date	

The real reason for this difficulty lies in the fact that surgeons have tried to state the end-results in terms such as "cured," "improved," etc., without reference to the time element. Actually, our patients are cured, or whatever the result may be, for variable periods of time, and it is just as absurd to try to state end-results in terms ignoring the element of time as it would be to attempt to state the area of a plot of ground in terms of one dimension.

All of the major difficulties of presenting the end-results disappear if we tabulate the results in terms of the time the patients have been traced following the operation, together with their state of health for the time periods. By this method the "cured" column becomes "years cured" and the term "years" is also added to the other divisions. It is also of advantage to add the headings "years operated" and "years traced" as illustrated in the accompanying table, which shows the results of tabulating 26 exophthalmic goitre cases operated by myself.

The mortality may be recorded either as "years dead" or by simply giving the number of deaths. In the cases here reported the operative and late deaths are given in separate columns, also the expected mortality in normal individuals for the same period is indicated.

TABLE I.—RESULTS FOLLOWING OPERATIONS FOR EXOPHTHALMIC GOITER.

Case No.	Years op.	Years traced.	Years cured.	Years satisfactorily improved.	Years improved.	Years unimproved.	Deaths.	
							Immediate.	Late.
2	10	3	....	....	3			
3	10	10	....	....	8	1	....	1
4	9 1/12	8 10/12	7 4/12	1 6/12				
5	8 11/12	8 5/12	6 11/12	....	6/12	1		
6	8 10/12	8 10/12	7 10/12	....	1			
7	8 5/12	8 2/12	6 2/12	2				
8	7 11/12	7 3/12	6 9/12	6/12				
9	7 8/12	1	....	....	6/12	6/12		
12	6 8/12	6 8/12	5	1 8/12				
13	6 6/12	5 9/12	5 1/12	8/12				
16	5 10/12	9/12	....	9/12				
18	5 8/12	4 9/12	....	....	....	....	1	
19	5 6/12	5 6/12	....	1 6/12	4			
21	5 4/12	5 4/12	4 4/12	1				
28	4 5/12	3 7/12						
30	3 9/12	2 5/12	....	....	2 5/12	....	1	
32	3 6/12	3 6/12	....	2 6/12	6/12	....	....	1
33	3 6/12	3 4/12	....	3 4/12				
40	2 5/12	1 5/12	....	....	1 5/12			
41	2 3/12	1 11/12	....	....	....	....	1	
42	2 2/12	1	....	1				
43	1 9/12	1 5/12	....	11/12	6/12			
44	1 9/12	1 7/12	....	1 8/12	4/12			
45	1 8/12	1 2/12	....	1 1/12	1/12			
47	1 5/12	1	6/12	6/12				
49	1	1	9/12	8/12				
Total	136 6/12	107 7/12	50 8/12	20 5/12	22 3/12	2 6/12	3	2

The advantages of this system of recording end-results are quite obvious. No matter how complicated the postoperative history, it can be readily subdivided and classified into the appropriate periods.

It is not necessary for the surgeon to trace each case to the time of reporting his results. If he has lost track of his patient soon after operation this fact is clearly shown by his figures and the value of the data may be judged accordingly. This method of completing end-result statistics is illustrated by Table I.

Formerly the most difficult of all cases to classify were the exophthalmic goiter cases. This was because almost no single case could be placed under a single heading. By the method here outlined even the exophthalmic goiter cases can be readily classified. The table shows 26 cases operated, a total of $136\frac{5}{12}$ years and traced $107\frac{8}{12}$ years. Of this time $50\frac{6}{12}$ years or 47 per cent., of the total traced postoperative time the patients have been cured. An additional $20\frac{5}{12}$ years, or 9 per cent., of the time the patients have been satisfactorily improved, making 66 per cent. of truly satisfactory results. $22\frac{3}{12}$ years, or 21 per cent., credited in the improved column, represent improvement to such an extent that the patients feel well repaid for their operations. Only $2\frac{6}{12}$ years, or 2 per cent. of the postoperative time, has been passed as unimproved.

In this series there are 3 early postoperative and 2 late deaths. The expected mortality for normal risks of the average age of the patients in this series is 0.963, or not quite 1 normally expected death.

GENERAL FACTORS INFLUENCING THE PROGNOSIS OF ALL SURGICAL DISEASES.

Age.—The influence of age on surgical prognosis is most important at the two extremes of life. The fact that the effect of age on the mortality of surgical diseases is essentially the same as the effect of age on disease in general enables us to make use of the enormous data collected by life insurance companies. Chart I has been compiled from the standard mortality tables of the life insurance companies for the purpose of graphically representing the effect of age on mortality. Although the data used for these tables is not obtained from surgical experience we believe that the curves here reproduced do show better than any other data available the effect of age *per se* upon the mortality factor in surgical prognosis.

An infant during the first year of life is a poor surgical risk. In general mortality statistics, most of the deaths are due to nutritional disorders not directly associated with surgical conditions, but nevertheless infants suffering from surgical diseases demanding operations at this early age are usually in a condition making them particularly liable, not only to the dangers incident to the operation itself, but to all the incidental dangers of this delicate age as well.

The general mortality of the second year is only about one-fourth that of the first year, and the prognosis continues to improve until, at about six years of age, the special dangers of early infancy and childhood have largely disappeared. Nevertheless, actuarial figures show a continued improvement up to the age of twelve. The mortality from all causes during the years from ten to fifteen is decidedly less than in any other period of years allotted to man.

Before passing to the consideration of the middle and later periods of life, it may be well to mention certain points of special surgical importance having a bearing on the prognosis of the early years of life.

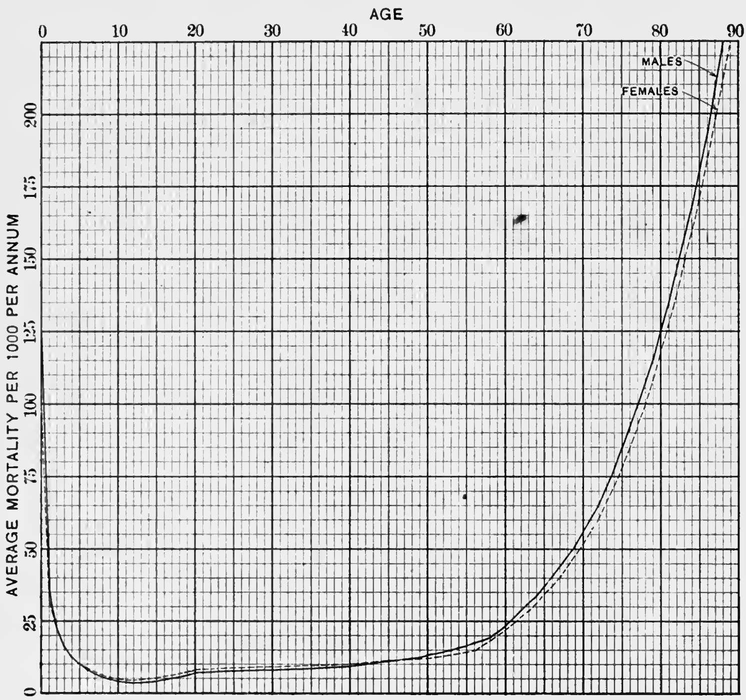


Fig. 1.—Relation of age to mortality risk.

Surgeons generally agree that children, and especially infants, bear hemorrhage badly. Yet when we take into consideration the naturally bloody character of a large proportion of the operations of general surgery undertaken on infants and children, and the proportionate amounts of blood available for loss in children and adults, it is difficult to prove a much greater relative inability to withstand hemorrhage in the younger patients. Certainly in the absence of other factors to produce or continue shock, the recovery of the average child from the effects of hemorrhage after such operations as tonsillectomy or staphylorrhaphy is very rapid.

Nearly all surgeons agree that children are particularly susceptible to shock, and this fact should always be borne in mind when operating on children. Nevertheless, operative interference of such magnitude as to be commonly associated with serious shock is seldom really imperative during childhood. In cases requiring extensive operative work the conditions are usually such that all need not be done at one time. Children much better than adults can afford the extra time consumed by operations carried out in several stages.

The susceptibility of the young baby to all those conditions interfering with its nutrition is known to all mothers, and the intensity of the metabolic processes throughout childhood make children, as a rule, more susceptible than adults to interference with their nutrition. Yet, if children are not too unruly, those suffering from intraperitoneal infections may be kept for a week or more on the Murphy drip, without food or drink by mouth, and after the cause of their illness has been successfully dealt with, it is remarkable how quickly they regain their weight and strength.

The prognosis of surgical tuberculosis is very much better in children than in adults. If the part can be kept at rest, bone tuberculosis, as a rule, heals spontaneously in children, while in adults radical excision of the diseased structures is usually required in order to effect a cure. Lymph gland tuberculosis in children heals spontaneously or after the simple removal of the more extensively involved glands, while in adults recurrences after operation for tuberculous lymph nodes are the rule, unless all of the glands in the region of the involvement are removed as well as the focus of primary infection in the tonsils or elsewhere.

In children the increased risks due to alcoholism and other excesses may be eliminated from our reckoning.

The child recovers very rapidly from the nervous phenomena accompanying the operation and postoperative neurasthenia is almost never seen.

Thrombosis and embolism are very rare after operations during childhood.

During *middle life* the mortality curve shows a gradually increasing risk with each succeeding year until in the forties the curve begins to ascend more rapidly. It is well to note that between forty-five and fifty-five years there is practically a 60 per cent. increase in the male mortality rate. These are the years which represent the period of the menopause in women. It is "the critical period for women" in the minds of the laity and most of the profession. But a careful examination of the table shows the rise in female mortality during this period is just as gradual as it was before. Much more startling is the appearance of the increase in the male mortality. Certainly this is *man's* critical period. The old doctrine that he too had a great climacteric is most strikingly shown. In the ten years from forty-six to fifty-six the gain in mortality per mille per annum for males is 6.32, while for females it is only 3.47. What are the causes for this greatly increased mortality among men? It is because his dissipations now begin to make themselves felt—especially alcoholism. The syphilis of his youth is just drawing its last check. The hardships of his occupation have now begun to bankrupt him. This is the period when habits and excesses begin to have a special importance in surgical prognosis.

After fifty the normal death-rate increases so rapidly that it is practically doubled with each succeeding decade. Thus, at fifty it is 13.01 per mille for males, at sixty it is 23.67, at seventy it is 55.64 and at eighty 124.93, or at the latter age approximately twenty times the normal death-rate for fifteen years of age.

In those past middle life, the effects of age on the individual prognosis must be estimated in conjunction with a knowledge of such ascertainable facts as the blood-pressure, the general condition of the heart and arteries, the findings of the urinary examination and the previous habits of the patient.

Sex.—The sex of the patient concerns more closely the incidence than it does the prognosis of surgical diseases. Most surgeons are convinced that women are, as a rule, better risks than men, and there is considerable data purporting to show that the operative mortality in diseases of certain organs not related to the sex of the patient, *e. g.*, gall-bladder surgery, is very much higher in the male than in the female. A study of this data, however, seems to show that the increased mortality in men occurs chiefly in the surgery of organs liable to be damaged by alcoholism and other excesses, and that males whose general resistance has not been undermined by irregular living are quite as good risks as females. Women are much less likely to be handicapped by these excesses.

The other noteworthy effects of sex on the prognosis have to do with the conditions involving especially the sex organs and will be discussed under the diseases of these organs.

Constitution.—As regards operative mortality there is little to choose between the slender, weak-muscled, nervous patient and the heavy, strong-muscled, calm, physically perfect individual. If anything, the advantage is liable to lie with the apparently weaker individuals unless the inferiority be due to actual disease. In them the technical part of the operation is usually easier, they seem to be better able to handle infection when it is present, and, as a rule, they are less liable to postoperative pneumonia and similar complications.

The great danger with the constitutionally weaker class of individuals lies not so much in the mortality as in the temptation constantly presented to the surgeon to try and accomplish the impossible in the way of making well and strong those who are fundamentally defectives. As W. J. Mayo has recently emphasized, the surgeon must not expect to make the man who is thin and six feet high into one who is fat and five feet six inches high by any operative procedure. Yet, if we study the history of surgery, especially during the past two decades, we cannot help but be impressed with the fact that many surgeons have been, and for that matter still are, actively engaged in trying to make over the thin, nervous, droop-bellied, visceral-sensitive woman into a strong normally innervated individual, usually by taking a tuck or two in the auxiliary supports of whatever organ may strike the fancy of the operator. The wise surgeon, who values his end-results and his lasting reputation as much as his mortality-rate and record of operations performed, places a very high value on the factor of "constitution" in so far as it may effect the final results of his work.

Neurotic Temperament.—The question of the nervous weakling has for years been one of great practical importance in surgery. The many terms which have been used to describe this class of patients illustrates the confusion which exists regarding them, and yet in general, the neurotic individual is not difficult to recognize. Most of them are physically below the average, and yet comparatively few actually show well-marked evidences of disease. Their complaints are always out of proportion to the objective evidences of gross pathology.

Many of these neurotic patients seem to be endowed with an abnormal visceral sense which makes them subjectively conscious of the workings of their internal organs and these visceral sensations come to occupy a large sphere in their mental processes. It is these *visceral hypersensitives* who make up a large proportion of the doubtful cases which the surgeon is called upon to diagnosticate and treat. Others are acutely sensitive beyond normal limits to all sorts of painful stimuli, and still others, the true neurasthenics, appear to be simply in a state of chronic nervous exhaustion. All of these types are continually seeking cure by surgical means, and operations devised for the purpose of curing them are continually being described.

In studying the history of surgical attempts to cure these cases we find surgeons at one time directing their efforts against the ovaries, while at another period uterine antiflexion was supposed to be the really important factor, and at still another period movable kidneys were looked upon as the most important cause of trouble—to say nothing of the chronic appendix. Recently tucking up the intestines was in great favor with a few operators, while others turned to resections of the colon. These periods of operative experimentation are mentioned because the fact should not be lost sight of that the surgeons were in each period dealing with essentially the same class of patients, and at no time have any considerable proportion of these patients been permanently benefited by surgery. The prognosis as regards mortality in these patients is usually excellent, but as regards cure from the viewpoint of the patient and the patient's relatives and friends these operations have been almost uniformly failures.

Surgically the nervous weakling should receive the same consideration as any other patient, no less and no *more*. Above all, real physical findings of disease should be the basis for operation and not the patient's account of his or her subjective sensations. It is seldom necessary to operate for pain alone. The subjective pain of the patient must be substantiated by some objective finding of the surgeon. Yet frequently we find surgeons operating for pain which they do not know to exist.

SPECIAL CONDITIONS AFFECTING SURGICAL PROGNOSIS.

Obesity.—Overweights are poor life insurance risks in almost direct proportion to the degree of excess weight, and the same handicap applies to these patients as surgical risks. A moderate amount of excess fat, as a rule, has little effect on the prognosis other than to increase the technical difficulties of the operation. With greater degree of obesity many difficulties and even dangers begin to make themselves manifest.

Excessive quantities of fat not only increase the technical difficulties of the operation, but the very presence of the fat in excessive quantities renders these patients bad subjects for either general or local anesthesia. The respiration is usually interfered with, and they take the anesthetic badly causing cyanosis, venous stasis and increased hemorrhage. Later these patients are particularly prone to develop postoperative pulmonary complications. Acute cardiac dilatation is a complication which may be encountered, especially if the patient be kept for any length of time in the Trendelenburg position. Fat embolism is another complication which probably occurs more frequently than is generaly recognized.

Fat is essentially a tissue of low vitality. Adipose tissue and obese individuals in general are notoriously little resistant to infection. Experimental observations have shown fat to be the least resistant tissue in the body to infection, and this has been abundantly confirmed clinically. It is likewise a particularly slow-healing tissue, the fat itself acting much as a benign foreign body while the repair proceeds chiefly from the interlobular connective-tissue septa. Whereas the serum exuded between two cut surfaces is an essential element in the healing process, oil pressed out from the fat and collecting between cut surfaces must first be removed before repair can proceed.

Ventral hernias and similar postoperative partial failures are more common after operations on the obese. This is due largely to the fact that the incision is called upon to support excessive strains incident to the increased weight while at the same time the tissues used in closing the wound are often so infiltrated with fat that they are soft and yielding. Another reason is that surgeons are prone to forget the slow repair in these patients. Obese patients should be kept in bed after laparotomies until adequate time has elapsed for the union of the slow-healing tissues.

Alcoholism.—The chronic alcoholic is a peculiarly unreliable surgical risk. All that life insurance companies say concerning the dangers of chronic alcoholism may be repeated with special emphasis as applying to the effect of alcoholism on operative prognosis.

These patients almost uniformly take an anesthetic poorly, and they are also notoriously bad subjects when it comes to resisting an infection of any kind. Postoperative pneumonia is a particularly dangerous complication for them.

The liability of the chronic alcoholic to develop delirium tremens after even minor accidents or operation is known to every hospital attendant. Particularly is this so after fractures, where it is possible that fat emboli, which in other patients would produce no symptoms, may play a part in the etiology.

The worst subject is usually the alcoholic between forty-five and sixty years of age. By this time many of the chronic alcoholics have reached a condition of general disintegration, when some otherwise minor disease is all that is necessary to carry them off, and if this trouble happens to be of a surgical nature they are very likely to be added to the surgeon's list of failures.

The alcoholic who survives sixty seems often to be made of tougher material than the average man, so that among old men alcoholism would appear to have less effect on the operative prognosis than it does among the middle-aged.

Heart Disease.—The laity and many general practitioners lay special stress on the dangers of general anesthesia in the presence of valvular heart disease. This belief is probably handed down from the days of relatively frequent chloroform fatalities. Certainly experience today, with ether given by the open drop method, is to the effect that well-compensated valvular lesions add very little if any risk to the anesthetic. Myocardial degenerations are, on the other hand, of considerable importance.

Willius,[1] in a recent paper, summarizes the experience of the Mayo Clinic as to the operative risk in cardiac cases as follows:

I. The decision of operability in cardiac disease depends on the factors as follows: (1) The immediate operative risk, (2) the probable improvement of the heart after operation, (3) the patient's relative chance for length of life or general health with and without operation, and (4) in less serious conditions, whether the operative relief will justify the added risk.

II. Cases in which the heart permits the patient to go about in relative comfort, or in which it can be sufficiently restored by treatment to allow this, usually are considered safe for operation.

III. Malignancy complicated by heart disease is usually considered operable if a fair hope of cure is offered.

IV. The best measure of operative risk is a good clinical impression of the patients' ability to stand physical strain, supplemented by a careful history and a thorough physical examination.

V. Preoperative medical therapy and rest combined with surgical and medical correlation after operation, is of paramount importance.

VI. The general tendency is to require too great a margin of cardiac safety in surgical work.

[1] The Operative Risk in Cardiac Disease, American Journal of Surgery, Oct., 1918.

Renal Disease.—The relationship of renal disease to surgical prognosis is one which must be approached with great caution. Albumin and casts are such frequent accompaniments of so many conditions requiring surgical treatment that they in themselves have little influence on the prognosis. On the other hand grave renal disease may be an almost absolute contra-indication to operation. In general, it may be said that the dangers depend upon the evidences of renal insufficiency rather than upon the results of the urine examination. Elective operations in the presence of demonstrable renal insufficiency should, as a rule, be approached with great caution or abandoned entirely, but if the condition of the patient be such as to actually demand operative interference the renal lesion may usually be discounted as a contra-indication to operation. The dangers of operating in the presence of uremia or on parts edematous with chronic renal disease cannot, of course, be overestimated.

The relation of renal disease to the surgery of the urinary tract will be discussed under the chapter dealing with this subject.

High Blood-pressure.—High blood-pressure is a symptom which should be given due weight in so far as it indicates grave cardiovascular or renal disease.

Low Blood-pressure.—A markedly low blood-pressure is always a dangerous prognostic sign in surgical cases. During and following operations it is a symptom of shock. Previous to an operation it may signify shock or hemorrhage or some grave asthenic condition. Except for the purpose of preventing further active hemorrhage, operations should very rarely be undertaken if the systolic blood-pressure is under 100 mm. Hg. A blood-pressure below 90 mm. Hg is almost a positive contra-indication to active operative interference.

Low Pulse-pressure.—The pulse-pressure should equal approximately one-third of the systolic pressure. In shock, grave hemorrhage and a number of other conditions affecting seriously the prognosis, the pulse pressure is found to be low in relation to the systolic. Patients having a pulse pressure of less than one-third of the systolic pressure should always be viewed with suspicion. A sudden fall in pulse-pressure during the course of a disease or following an operation is a grave prognostic sign.

Diabetes.—Diabetics are notoriously bad surgical risks. Wound infection, non-healing and diabetic coma are the three dangers peculiar to operations on diabetic patients. Of these coma is by far the most frequent and the most difficult to prevent. Karewski reports 136 operations on diabetics with a mortality of 20 per cent. and of these 78 per cent. died in coma.

Sepsis and non-healing can be very largely controlled by the use of a rigid aseptic technic and great care to avoid unnecessary trauma to the tissues.

For many years surgeons generally have held to the belief that if the diabetic patient could be rendered sugar-free, an operation could then be performed with relative safety. This idea was based largely on the work of Phillips[1] who in 1902 reported a large series of cases from the literature showing a mortality of 36.37 per cent. in cases not subjected to preoperative treatment and 17.7 per cent. in treated cases. More recently it has been shown that the well-known dangers accompanying attempts to render the urine sugar-free in medical practice hold with equal force in surgical work and that preoperative dietary treatment unless it is surrounded with all the safeguards known to the medical treatment of this disease is likely to actually increase the dangers of coma.

The dangers of operating in the presence of diabetes can scarcely be overestimated and yet under certain conditions the diabetic seems to offer but a moderately increased operative risk. Fifty per cent. of the postoperative coma cases reported by Karewski were in so-called mild diabetics and it may be said that the factors governing the selection of safe operative risks in the presence of this condition are not yet fully understood. In general it may be said that no diabetic should be operated, except in the gravest emergency without first demonstrating the patient's ability to maintain a sugar-free urine without developing any of the well known acidosis complications of the disease.

Acidosis.—This term has been used to designate conditions varying in importance from the slight increase in the H-ion concentration of the blood which follows severe exercise to the grave acid intoxications of the type encountered in diabetic coma. Theoretically acidosis explains certain phases of the abnormal physiology encountered in many serious conditions. As a rule the underlying causes of the acidosis are readily recognizable and when acidosis is demonstrable in the presence of these causes the prognosis is serious and when possible the operation should be postponed until the acidosis can be remedied. Occasionally the surgeon encounters patients suffering from a grave acidosis without the underlying disease being apparent.

Russ[2] states that the warning signs in such cases are:

1. A history of unaccountable headaches, vertigo, attacks of dyspnea, occasional nausea or vomiting, an unreasonable dread of the operation, tachycardia and other nervous symptoms.

2. A peculiar sweetish odor to the breath, suggesting the odor of rotten apples. In some cases this is marked and unmistakable.

3. The presence in the urine of the acetone bodies.

He further says that to disregard these warning signs is to subject the patient at best to (1) an anesthesia requiring large amounts of ether or chloroform and attended with struggling and great rigidity of the muscles, difficult breathing, a rapid pulse and nausea and followed by a prolonged and nerve-racking convalescence, with persistent vomiting, restlessness, dyspnea, a rise in temperature and much suffering; or, if less fortunate, to (2) the certainty of a fatal termination, preceded by nausea, air-hunger, persistent vomiting, a

[1] Surgical Aspects of Glycosuria and Diabetes, Lancet, 1902, i, 1308–1386.

[2] Acidosis as a Complication after Surgical Operations, Jour. Am. Med. Assn., 1913, lxxxi, 1618.

rise in temperature, great nervousness and followed by coma and death in from ten hours to two or three days.

The writer[1] has had one postoperative death due to this cause, and can recall three other deaths which were probably due to this condition. As a complication in surgical work acidosis is undoubtedly rare and the data so far available concerning it is by no means conclusive, and yet as surgeons learn to eliminate the more common causes of failure these rare conditions assume greater relative importance.

Intestinal Auto-intoxication.—Few subjects in medicine or surgery have been more written about with less clear understanding than has the question of auto-intoxication of intestinal origin. Some even claim that the victims of this condition are bad general surgical risks prone to all sorts of complications. It would seem, however, that in all but the most severe grades of the condition its effect on the immediate operative prognosis is of but very slight importance.

It is in connection with the question of the ultimate prognosis of operations performed for other conditions and those directed toward the relief of this condition that the subject of intestinal auto-intoxication assumes great practical importance. That the surgical end-results in cases operated for the various phases of so-called auto-intoxication have up to the present time been often unsatisfactory is generally accepted. Furthermore, it seems highly probable that the results will remain unsatisfactory until some really definite knowledge is obtained concerning the etiology of the condition. Up to the present time no really definite proof of the actual existence of intestinal auto-intoxication as a clinical entity has ever been demonstrated. Is the constipation which is usually present the cause of the diseased condition or is the primary disease or defect, whatever it may be, the cause of the intestinal derangement? In spite of much literature on the subject this question has not yet been answered.

Hemophilia.—This rare condition may lead to serious or even fatal hemorrhage after operation which under other circumstances would be considered most minor surgical procedures. Within recent years excellent results have been reported from the use of alien or human serum injections or better the transfusion of whole blood given with the idea of adding to the blood of the hemophiliac those substances essential for thrombus formation which are ordinarily lacking in the blood of these patients.

In this connection it might be well to emphasize a point concerning the use of serums or blood in general to control the hemorrhagic tendencies associated with this and other conditions, and that is that thrombus formation and even ordinary coagulation are very complex processes. Recent investigations have shown that they are really resultants of the action of many substances, and that because borrowed serum supplies the missing link in one case is no reason why it should be expected to give equal results in other cases of diverse origin. The outcome in

[1] Analysis of Deaths in 1573 Surgical Operations, Albany Med. Ann., August, 1914, p. 432.

one case may be excellent and in another altogether disappointing, depending upon factors, as yet none too well understood, and requiring careful study in each individual case before any operative procedure should be undertaken.

Jaundice.—Jaundice in itself indicates the presence of a serious pathological condition so that, irrespective of the special dangers incident to the jaundice *per se*, the prognosis in the presence of jaundice should always be guarded. Aside from the dangers incident to those pathological conditions which may be primarily responsible for the jaundice, there are two additional special dangers which must always be reckoned with when operating on these patients. The first is referable to the liver itself and is probably the result of an interference with the liver function due to a sudden relief of pressure in the biliary ducts. The phenomenon is undoubtedly similar in kind to the renal failure frequently noted after suddenly relieving the urinary pressure in long-standing cases of urinary obstruction. The danger of this grave complication is always present when operating on the biliary tract in the presence of obstructive jaundice. A fatal postoperative termination, the direct result of hepatic failure, is an almost invariable rule in cases in which the obstruction has persisted until only a clear watery fluid is found in the bile ducts at operation.

The second danger associated directly with jaundice is hemorrhage. Operations performed in the presence of jaundice are, under certain circumstances, liable to be followed by prolonged oozing from vessels which under ordinary conditions would scarcely bleed at all. Jaundice is not always associated with this tendency to hemorrhage. The majority of jaundiced patients coming to operation are not noticeably bad bleeders, and yet in these patients the possibility of this dangerous condition must always be borne in mind.

The causes of the hemorrhagic condition associated with jaundice are not well understood. In general it bears a relation to the duration and intensity of the jaundice but this relationship is not fixed and there may be wide fluctuations in the hemorrhagic tendency in individual cases without known cause. These patients frequently bleed to death from simple trocar punctures. In deeply jaundiced patients with evidences of purpura the danger of hemorrhage has usually been considered, along with the other dangers associated with this condition, almost an absolute contra-indication to operation. In these cases the operative mortality is so high as to be prohibitive while under conservative treatment a fair proportion ultimately clear up provided the obstruction be not due to malignant disease.

Within recent years Munro,[1] Moynihan[2] and others have claimed good results in the way of controlling the hemorrhage by the injection of alien serum before and after the operation, and equally good results have been claimed from the similar use of blood or serum obtained from normal individuals. The factors governing success or failure

[1] Boston Med. and Surg. Jour., March 25, 1909.
[2] British Med. Jour., October 2, 1909.

are not thoroughly understood and frequent failures are reported alongside of the successes.

The writer[1] has had one death from anaphylactic shock following the use of rabbit's serum in a case of jaundice.

Anemia.—If we exclude from consideration at this time the acute anemias, the result of sudden hemorrhage, it may be said that the effect of anemia *per se* on the operative prognosis is in almost direct proportion to the grade of the anemia. The lesser grades of anemia have little direct effect on the prognosis other than to indicate the possibility of a more prolonged postoperative convalescence. The more severe grades of anemia affect the prognosis in two ways: In the first place the presence of a well-marked anemia is usually of itself an indication of the presence of some serious disease capable of causing the anemia. In the second place the more severe grades of anemia considerable increase the dangers accompanying any operative procedure. Mikulicz believed that no operative work requiring a general anesthesia should be undertaken in a patient with less than 30 per cent. of hemoglobin. Certainly no operation should be undertaken in the presence of extreme anemia unless the patient is suffering from some form of continuing hemorrhage not controllable by non-operative means. In most cases of severe anemia it is better to keep the patient under conservative treatment until the condition of the blood can be improved to such an extent as to make the operation safe. In all cases of severe anemia the possible use of blood transfusions should always be kept in mind.

This does not, however, mean that a patient who is already a reasonably good operative risk should be kept for a long time under conservative treatment subject to the dangers of the disease itself if a more rapid improvement could be confidently predicted after operation. As a rule, if the hemoglobin is over 50 per cent. the special dangers due to the anemia are not such as to warrant prolonged delay unless there is little danger in delaying the operation and the general condition of the patient is improving at least approximately as rapidly as could be expected after operation.

Acute Bronchitis.—In the writer's experience ether given to patients suffering from acute bronchitis has almost invariably resulted in an exacerbation of the pulmonary trouble. This exacerbation is always distressing to the patient, if not actually dangerous, and should be avoided if possible by postponing the operation until such time as the patient has recovered from his bronchitis. If the patient with acute bronchial trouble must be operated some form of anesthesia other than inhalation ether anesthesia should be selected if possible. Local novocain or spinal anesthesia are the methods usually selected.

In contrast to acute bronchial infection the more chronic pulmonary troubles, even those associated with empyema and pulmonary abscess, are often but little influenced by the anesthetic.

[1] An Analysis of Deaths in 1573 Surgical Operations, Albany Med. Ann., August, 1914, p. 442.

Surgeons differ in their opinions concerning the dangers of operating in the presence of pulmonary tuberculosis. It is certain, however, that a general anesthetic never does the condition any good, and that following operations exacerbations of the pulmonary lesions are frequently noted due either to the anesthetic or to a postoperative period of lowered immunity against the disease.

THE PROGNOSIS OF THE OPERATION ITSELF.

Accidents and Complications Associated with Surgical Operations.—Every surgical operation has associated with it a certain element of risk, (1) as regards the life of the patient, and (2) as regards the danger of unforeseen complications resulting in a more or less serious disability directly traceable to the operation. The danger may be so slight as to be almost negligible, nevertheless, it is the duty of the surgeon in each individual case to carefully estimate the risks involved before undertaking any operative procedure no matter how simple or how extensive it may be. This is necessary not only that he may arrive at a correct decision for or against the operation, but because the more carefully the estimate is made the better will the surgeon be prepared to avoid those complications which are liable to interfere with the results of the operation.

In order to get a clear understanding of the factors influencing the prognosis of the operation itself it is necessary to discuss separately each of the accidents and complications which may interfere with the outcome of the operation. The list is a formidable one, and unless the reader constantly bears in mind the fact that he who is forewarned is forearmed, it is difficult not to overestimate the combined dangers associated with most surgical operations.

Table II has been prepared for the purpose of showing the mortality of a number of typical operative procedures. This table was purposely compiled from data representing the work of surgeons of concededly more than average ability so as to show what can be accomplished at the present time. Similar compilations from the reports of many of the smaller hospitals throughout this country would seem to show that the average mortality of the average operator is at least two and in some cases three times that shown in the table.

The influence of the disease itself on the operative mortality is well illustrated in the results of operations for hernia and appendicitis. Only 13 patients died following 5984 operations for non-strangulated hernia or 1 in 460 patients operated upon, while among 694 patients operated upon for strangulated hernia at St. Thomas' Hospital (London)[1] between 1900 and 1909 there were 120 deaths or 1 in 5.8. Following 3584 operations for interval and chronic appendicitis in several American hospitals there were only 5 deaths or 1 death in 717 operations. After 9440 operations for acute appendicitis reported in

[1] Battle, W. H.: Lancet, October 12, 1912, p. 999.

the last few years by individual operators in this and foreign countries, there were 687 deaths or 1 death in 13.6 cases. All studies of the mortality following operations for acute appendicitis show that the great majority of the deaths occur in cases accompanied by peritonitis at the time of operation.

TABLE II.

Character of operation.	Operation.	Deaths.	Proportion.
Radical operations for non-strangulated hernia	5984	13	1 in 460.0
Operations for strangulated hernia	694	120	1 in 5.8
Laparotomies for chronic appendicitis	3584	5	1 in 717.0
Laparotomies for acute appendicitis	9440	687	1 in 13.6
Laparotomies for miscellaneous gynecological affections	2497	33	1 in 76.0
Abdominal hysterectomies for myoma	1843	73	1 in 25.6
Abdominal myomectomies	453	17	1 in 26.6
Laparotomies for gall-stone disease	5051	197	1 in 25.6
Operations for non-perforated duodenal or pyloric ulcer	1417	26	1 in 54.5
Suprapubic prostatectomy	1442	95	1 in 15.2
Perineal prostatectomy	1000	61	1 in 16.4
Operations on kidney and ureter	705	14	1 in 50.0
Radical operations for carcinoma of the breast	1063	3	1 in 354.0
Thyroidectomy for simple goiter	1893	6	1 in 315.0
Operations for tuberculous cervical lymph nodes	465	1	1 in 465.0
Partial gastrectomy for carcinoma	234	31	1 in 7.6
Partial resection large intestines for carcinoma	159	26	1 in 6.1

Anesthesia.—In estimating the effect of the anesthetic on the operative prognosis it is necessary to consider both the immediate dangers occurring during the administration of the anesthetic and the more remote effects of the anesthetic such as the lowering of the vital powers of resistance against infection, the relation of the anesthetic to postoperative lung complications, and the effect of the anesthetic on such organs as the kidneys and liver.

Although carelessness or incompetency in the administration of any anesthetic makes that individual anesthesia dangerous, it has been abundantly proved that with a competent anesthetist the immediate dangers due to the anesthetic itself, when employing one of the standard methods of local or general anesthesia, is so slight as to constitute almost a negligible factor in the prognosis of the individual case. Table III, compiled by Dr. James T. Gwathmey[1] shows the relative proportion of fatalities to the number of anesthesias in 278,945 cases reported from American sources.

Ether.—In more than half of the anesthesias reported in this table ether was given by the open drop method with a mortality of one death in 5623 cases. This figure is considerably higher than that given in the much quoted statistics of Hewett, *i. e.*, 1 death in 16,302 ether anesthesias, but the higher death-rate undoubtedly is much nearer the true average under ordinary conditions. The facts are that the risk is not definable in terms of statistics but rather in terms of the skill and care of the anesthetist. Ether properly administered

[1] Jour. Am. Med. Assn., 1912, lix, 1846.

TABLE III.—AMERICAN STATISTICS.

Anesthetic.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	Total.	Deaths.	Percentage.
5. Local anesthesia	1,422	1,882	1,881	2,462	2,458	2,611	2,092	14,878	0	0–14,878
6. N_2O with oxygen	144	175	335	881	1,619	2,130	3,301	8,585	0	0– 8,585
10. Anesthol-ether anesthesia	152	406	435	584	559	772	919	3,827	0	0– 3,827
13. Ethyl chloride, drop sp.	67	102	133	97	115	136	255	905	0	0– 905
14. N_2O with air	51	90	.....	40	90	.....	290	561	0	0– 561
15. Spinal analgesia	66	43	86	64	34	63	165	521	0	0– 521
18. Anesthol-ether-$CHCl_3$	....	17	52	27	18	39	.....	153	0	0– 153
19. Anesthol-chloroform	....	.....	.....	67	28	28	.....	123	0	0– 123
20. Nitrous oxide, ether-anesthol	....	.....	75	16	14	9	.....	114	0	0– 114
21. Essence orange-ether seq.	....	.....	.....	.....	.....	.....	100	100	0	0– 100
22. $A_1C_2E_3$ or C_2E_3 mixture	2	2	.....	.....	.....	6	85	95	0	0– 95
23. Ether-$CHCl_3$ sequence	3	18	10	1	15	13	34	94	0	0– 94
24. Nitrous oxide-anesthol	....	32	8	.....	3	2	.....	45	0	0– 45
25. Ethyl chloride-anesthol	....	25	2	.....	.....	14	.....	41	0	0– 41
26. Anesthol-oxygen	15	.....	16	...	.....	4	2	37	0	0– 37
27. Ethyl bromid anesthesia	12	8	.....	...	.....	.....	.....	20	0	0– 20
28. Ethyl chlorid-oxygen	....	.....	.....	...	1	2	10	13	0	0– 13
29. M-H-C anesthesia	....	.....	9	...	.....	.....	.....	9	0	0– 9
4. Chloroform-ether sequence	756	1,374	1,770	1,641	3,022	3,804	3,687	16,054	2	1– 8,027
2. Nitrous oxide-ether sequence	2,359	2,576	4,147	4,991	11,274	6,703	9,385	41,435	6	1– 6,905
7. Anesthol	1,132	880	956	1,271	782	648	470	6,139	1	1– 6,139
1. Ether, drop or vapor	7,523	12,279	15,154	19,322	23,049	26,145	53,981	157,453	28	1– 5,623
8. Ethyl-chloride-ether sequence	199	169	467	477	872	1,135	1,012	4,331	1	1– 4,331
9. $CHCl_3$-oxygen	401	472	664	673	461	660	678	4,009	1	1– 4,009
3. $CHCl_3$, drop or vapor	3,048	2,557	2,532	2,339	1,910	2,080	1,924	16,390	8	1– 2,048
11. Nitrous oxid	111	84	203	216	198	206	296	1,314	2	1– 657
16. Rectal anesthesia	....	.....	.....	60	129	152	175	516	1	1– 516
12. Intratracheal insufflation	....	.....	.....	...	.....	.....	1,000	1,000	4	1– 250
17. N_2O-ether-chloroform anesthesia	4	.....	.....	7	12	20	140	183	1	1– 183
								278,945		

is so safe that series of 15,000 or even 20,000 consecutive cases without an anesthetic death are not uncommon. The writer has never witnessed an ether fatality in the hands of a competent anesthetist, and yet I have personal knowledge of 7 ether fatalities in the hands of students or inexperienced internes representing a mortality of about 1 in 500 for ether anesthesias given by incompetent anesthetists.

Chloroform.—The figures given for chloroform, *i. e.*, 1 death in 2408 anesthesias agree approximately with other statistics from general sources although chloroform statistics vary greatly. Lawrie[1] reports 30,000 chloroform anesthesias without a death. In some British hospitals the death-rate is said to be as high as 1 in 250 cases. German statistics give 1 in 2200. U. S. Army figures give 4 deaths in 3931 operations. Hewett reports 214 deaths in 676,767 administrations, or 1 in 3162.

Nitrous Oxide and Oxygen.—The figures given for nitrous oxide and oxygen, *i. e.*, not any deaths in 8585 anesthesias show the possibilities of this form of anesthesia, which is undoubtedly one of the safest of the general anesthetics in the hands of the experts, and at the same time one of the most dangerous when used by the novice. The attempt a few years ago to make general use of this form of anesthesia certainly resulted in a very much higher death-rate than that shown by the figures here quoted.

Spinal Anesthesia.—Babcock,[2] in a summary of the subject of spinal anesthesia, gives the following conclusions based on a personal experience of over 5000 cases:

"In our personal experience ether and spinal anesthesia have been about equally dangerous, ether from exigencies compelling a profound narcosis or an imperfectly trained anesthetist; spinal anesthesia from an unwise selection of patients and an imperfect knowledge as to the physiological action of the drug. With careless or unskilled use, spinal anesthesia is doubtless much more dangerous than ether.

"The morbidity of spinal anesthesia as expressed by nausea, vomiting, headache, backache, postoperative pain, and albuminuria is less than that from ether.

"Ocular palsy may result from spinal anesthesia where contaminated or deteriorated solutions are used. A lateral deviation of the needle with injury to a nerve root may be followed by severe neuritis and secondary palsy.

"Secondary degeneration of the spinal cord from the chemical action of stovain, properly introduced within the arachnoid in human beings, for purposes of spinal anesthesia is doubted.

"Functional or neurotic symptoms occur after spinal anesthesia as they do after etherization, and may, to the annoyance of the surgeon, be attributed by the patient to the injection.

[1] Bull. Johns Hopkins Hosp., January, 1895.

[2] The Dangers and Disadvantages of Spinal Anesthesia, New York Med. Jour., November 8, 1913.

"If a steel needle be used it may be broken under the skin during the injection.

"Danger symptoms may follow if the patient be moved immediately after the injection or if the proper posture to prevent the anesthetic from reaching the upper nerve roots be not maintained for at least one half hour after the injection.

"Repeated intradural injections seem to be harmless.

"Spinal anesthesia is dangerous in circulatory subtension, conditions greatly depressing the respiratory centers, shock, collapse, advanced myocardial disease, and large intrathoracic effusions. It is more dangerous for operations upon the upper abdomen than those upon the lower. It does not obviate the danger of sudden cardiac arrest in operations for large uterine fibroids."

The experience of Babcock and a number of other surgeons who have had extensive experience with this form of anesthesia has proved that in expert hands its dangers are very slight. Equally good results have not, however, been obtained by surgeons who have attempted to make occasional use of spinal anesthesia.

The Remote Effects of Anesthetics.—With the gradual elimination of the more immediate dangers associated with anesthesia surgeons have begun to pay more attention to the influence of the anesthetic on the postoperative morbidity and mortality, especially as regards its influence on the kidneys, liver, lungs and the central nervous system, and also as regards its effect on the vital forces concerned in the resistance against infections.

Effect of Anesthetics on the Kidneys.—At least one-third of all ether anesthesias are followed by albumin and casts in the urine, persisting, as a rule, for several days. Animal experiments have shown that ether when administered in sufficient quantities to produce general anesthesia is a distinct irritant to the kidneys in approximately direct proportion to the amount of anesthetic employed and the duration of the anesthesia. Clinical experience has, however, demonstrated that in the great majority of surgical patients the slight effect of the ether on the kidneys is of little or no prognostic significance.

Chloroform is generally understood to be distinctly less irritating to the kidneys than ether.

Nitrous oxide is said to have practically no effect upon the kidneys. It has, however, a marked effect in cases suffering from arteriosclerosis.

Cocain and its derivatives used as local anesthetics have no effect upon the kidneys.

Cases of anuria following operations other than those on the urinary tract are very rare, and it is now known that many cases of anuria following operations on the urinary tract, which were formerly ascribed to the anesthetic, were in fact due to causes entirely apart from the anesthesia.

The Effect of Anesthetics upon the Liver.—The general effect of the several anesthetics upon the liver is probably not essentially different from that exerted by them upon the kidneys. In most cases it is of little known importance. Within recent years a number of writers have reported cases of so-called delayed chloroform poisoning accompanied by very serious pathological changes in the liver simulating those found in acute yellow atrophy. This condition is, however, so rare as to have practically no influence on the prognosis of chloroform anesthesias.

The Effect of Anesthetics upon the Lungs.—Postoperative lung complications are among the most frequent and serious of the postoperative sequels, yet the exact role played by the anesthetic in these cases is still open to question. Attempts to show any well-marked difference in the frequency of the more serious pulmonary complications following the use of different forms of anesthesia have not yielded conclusive results.

Ether is generally conceded to be the most irritating of the general anesthetics, and the minor grades of bronchial irritation are certainly relatively more frequent after ether anesthesia.

The Effect of Anesthetics upon the Nervous System.—Notwithstanding the fact that the physiological activities of certain portions of the nervous system are profoundly altered during all forms of anesthesia, actual injury to the nerve cells or nerve fibers does not seem to occur under ordinary circumstances. In fact the state of physiological rest enforced by the anesthesia seems to protect those portions of the nervous system acted upon by the anesthetic from the fatigue changes of overstimulation which would otherwise result from the operative manipulations.

The Effect of Anesthetic upon Immunity Factors.—This is one of the most important questions related to anesthesia, and yet it is one concerning which there is very little definite data available. There is, however, abundant clinical evidence to show that a prolonged ether anesthesia has a decidedly deleterious effect on those complex immunity factors which go to make up the body's power to resist infection. The effect is probably similar in kind to that observed after an alcoholic debauch, when it is a well-known clinical observation that there is a temporary reduction of the natural immunity against the pyogenic infections as well as gonorrhea, typhoid and probably all other infections.

There is practically no data concerning the effect of chloroform on immunity.

Nitrous oxide and the local anesthetics are said not to appreciably lessen the natural powers of resistance.

Postoperative Nausea and Vomiting.—The surgeon is liable to give scant consideration to the nausea and vomiting which so frequently accompany anesthesia, and yet to the patient it is usually one of the most distressing features of the operation and one which cannot be entirely ignored in considering the postoperative prognosis. With ether it can only be reduced by shortening, as much as possible the duration of the anesthesia, and by giving the least possible amount of the anesthetic.

While it is undoubtedly true that chloroform gives rise to nausea and vomiting far less frequently than does ether, it is claimed by some that when these symptoms do occur following chloroform anesthesia they are of a much severer type. After nitrous oxide nausea and vomiting are of almost negligible importance.

Hemorrhage.—Dieffenbach has said: "From the behavior of a surgeon in cases of severe hemorrhage are we able to judge of what metal he is made."

The intelligent management of hemorrhage demands more than the mere technical ability to control bleeding vessels. Ideal surgery would be bloodless, or nearly so, yet a certain and sometimes considerable loss of blood is the price which must be paid for the successful completion of many operations. Along with the technical ability to control hemorrhage it is most important that the surgeon be able to estimate at any instant the balance between blood assets and actual or probable blood losses in the patient he is operating. A great many operations have been incompletely performed because the surgeon became frightened in the presence of an amount of hemorrhage, which under the circumstances, was of little relative importance. On the other hand, many patients have lost their lives because the operator failed to realize the immediate importance of what under other circumstances might have been a relatively unimportant loss of blood.

The amount of blood which can be lost without death ensuing has been the subject of extensive observation and experimentation. The total quantity of blood in the body has been determined as amounting to approximately 7.7 per cent. (one-thirteenth) of the body weight. That is, a man weighing one hundred and fifty pounds has approximately five quarts of blood. The amount which can be lost depends upon a number of factors, so that it is impossible to say that 10 or 20 or 40 per cent. can be lost without death ensuing.

The immediate source of danger from hemorrhage is the fall of blood-pressure to a point at which the circulation cannot be maintained. Up to a certain point the effect of the loss of blood on the blood-pressure can be neutralized by a general contraction of the peripheral vessels, but the mechanism by which this adaptive process is carried out requires an appreciable element of time for its consummation. Sudden hemorrhages are, therefore, much more serious in proportion to the amount of blood lost than are slow hemorrhages which allow time for the adaptive mechanism to keep up with the loss of blood. "The effect upon the blood-pressure is most sudden in venous hemorrhage from the large venous trunks because the quantity of blood supplied to the heart is more immediately reduced, the cardiac output being directly proportional to the venous pressure. The blood-pressure is only a quarter of a pound to the square inch in the veins, whereas in the arteries it amounts to four pounds to the square inch or from ten to sixteen times that in the veins."

The sudden gush of blood, even though it be controlled before the total loss has reached an otherwise considerable amount is always dangerous because of the collapse which is liable to ensue. On the other hand, during the course of a prolonged operation a much greater total loss of blood may be borne by the patient without producing serious symptoms.

Individual patients undoubtedly vary greatly as regards their ability to withstand hemorrhage. Women, as a rule, withstand hemorrhage better than men, and hemorrhages from the uterus often seem to be borne better than equally rapid and severe hemorrhages from other sources. Children may die after losing relatively small amounts of blood and old people are particularly susceptible, probably because their sclerotic vessels do not aid in the adaptive contraction of the peripheral vessels.

The best guide to the immediate prognosis in cases of recent hemorrhage is the blood-pressure, for if this be maintained it matters little what the red cell count or the hemoglobin index may be.

The anemia resulting from hemorrhage is usually of minor importance. The loss of 50 c.c. which is a fair average for an ordinary operation is immediately replaced out of the reserve fund of the vascular system (Arneth). In surgical conditions it is very seldom that over 3 per cent. of the blood is lost (Crile) and after severe hemorrhage the regeneration is usually complete in from nineteen to twenty-four days (Lyon). Regeneration is said to be most rapid in adult males (Matas). Exhaustion of the blood regenerating organs, the result of long-continued hemorrhages previous to the time of operation, may greatly retard the process of regeneration. Likewise the presence of any systemic disease ordinarily accompanied by anemia will retard the regeneration of blood lost at the time of operation.

Secondary Hemorrhage.—The elimination of sepsis, the selection of more suitable ligature materials, and a better understanding of the principles governing the ligation of vessels has very largely eliminated the dangers of secondary hemorrhage in most fields of surgery. There are today, however, certain operations which are followed by secondary hemorrhages with sufficient frequency for this complication to have a definite influence upon the prognosis of these operations.

Few surgeons of experience but have encountered secondary hemorrhages following amputation of the cervix. These hemorrhages are seldom rapidly fatal and can be readily controlled in the great majority of cases.

Considering the large number of tonsil operations performed, dangerous secondary hemorrhages are rare and when they do occur they can usually be brought under control without great difficulty.

Hemorrhage following goiter operations is nearly always due to slipping of the ligature applied to the superior thyroid. This accident is usually caused by including fibers of the overlying muscle in the ligature. The accident is very serious and can only be avoided by faultless primary ligation of the vessel.

Secondary hemorrhage following prostatectomy is relatively frequent and always of serious import owing to the difficulty of controlling it and the fact that prostatic cases are usually very poor subjects for hemorrhage.

Nephrotomy is not infrequently followed by secondary hemorrhage which may be rapidly fatal. It is always difficult to control and often requires secondary nephrectomy.

Hemorrhage after gastro-enterostomy and similar operations on the gastro-intestinal tract constitutes one of the chief dangers in this field of surgery. These can only be avoided by most careful suturing. Crile has recommended the use of the shoemakers' stitch in intestinal work because of the control it gives of the vessels in the intestinal wall.

No discussion of hemorrhage is complete without calling attention to the results obtained by direct transfusion in the treatment of these cases. Many cases are lost that might be saved by timely transfusion. In our experience the citrate method has been entirely satisfactory and quite as easy to give as an intravenous injection of salvarsan. When possible the donor should be selected according to approved compatability tests. When these tests have not been possible we inject very slowly 5 to 10 c.c. of the citrated blood of the donor into the recipient and then wait five or six minutes. Symptoms of incompatability develop very promptly and are readily recognizable so that if no reaction develops in five or six minutes it is usually quite safe to proceed with the injection of the maximum quantity of blood.

Shock.—"Shock may be defined to be a depression of the vital powers, induced suddenly by external injury, and essentially dependent upon a loss of innervation." (S. D. Gross.)

In the more than half a century which has elapsed since the publication of Gross's *System of Surgery* our conception of shock has not materially changed or have we greatly increased our knowledge of the elemental causes of shock. "Shock may be produced by a great variety of causes, some of a bodily, others of a mental character; some external, others internal. It may be purely nervous, or partly nervous and partly hemorrhagic, that is, dependent upon the conjoined loss of nervous and sanguineous fluids. The nature and extent of shock are greatly influenced by the state of the general health at the time of the accident, the amount of injury, the importance of the part more directly assailed, and, also, in a special manner, by the idiosyncrasy of the individual. There are some persons, soldiers, for example, of the most undoubted courage, men who would not hesitate to face the mouth of the cannon, who fall into a state of the most profound prostration from the most trifling accident; who turn pale and tremble like a leaf; whose minds are perfectly bewildered, and who are, as it were, completely stunned, from injuries so insignificant as not to affect, in the slightest degree, ordinary persons. Such an occurrence can only be explained by a reference to idiosyncrasy; and it has its counterpart in those persons who, although extremely plethoric, faint from the slightest loss of blood, or even from the mere sight of that fluid. There are other persons, on the contrary, whom hardly any accident, however severe, can shock; they are insensible to pain; their nervous system is obtuse; nothing affects them, either bodily or mentally; a severe blow may stun them, but the effect is transient; in a few minutes they are completely restored to consciousness and power. Here, again, is an example of idiosyncrasy, a peculiarity of organization; in the former case, the individual is all nerve, all sensibility; in the latter, all blood, all muscle.

"Mental shock is often extremely severe, and is occasionally followed by the worst consequences, especially when it occurs during the progress of a severe illness, or after a severe surgical operation. Fright is perhaps the worst of the causes of mental shock. The effect of terror, in suddenly exhausting nervous power, is well illustrated by the history of those persons, who, being sentenced to be bled to death, actually died on hearing water trickling into the basin, which they supposed to be blood issuing from their veins, after the arm had been slightly pricked, although no vessel had been opened. It is related of Dessault that he one day lost a patient, about to be lithotomized, from sheer fright. The man, who was very cowardly, fainted and died under the impression that the operation was progressing, when this distinguished surgeon was, in fact, only tracing with his nail the line of the intended incision on the perineum.

"Mental and corporeal shock are often combined; and, when this is the case, it is not uncommon to see the former predominate, in a very marked degree, over the latter. The soldier on the field of battle may suffer from bodily shock induced by a severe wound; he may feel that he is badly hurt, but still he is sanguine of recovery, and cheerfully and manfully bears up under his affliction. The surgeon examines his wound and perceiving its grave character, informs him that it will probably cost him his life. Instantly the case assumes a different aspect; the system is overwhelmed with perturbation and excitement; the vital powers are depressed to the utmost; and death takes place perhaps several days sooner than it would otherwise have done." (Gross.)

During the World War, the opportunities for observing and studying shock were almost unlimited. As a result of these observations we have learned to differentiate more sharply between the true surgical shock resulting from traumatism, psychical shock and hemorrhage. At present it would seem that the best working hypothesis explaining the phenomena attending shock is that the underlying cause of shock is due to a diminution in the normal alkalinity of the blood. This hypothesis gives a rational basis for the prevention and treatment of shock which has apparently stood the tests of experience as encountered in war practice.

In accident and military surgery shock is still encountered with much the same frequency as in the time of Gross, but today serious life-threatening shock has been, to a very great extent, eliminated from deliberately planned operative surgery. This improvement is due to a better understanding of the mechanism of shock and how to avoid the causes responsible for its production; also, to the fact that surgeons have learned what may and what may not be done under given circumstances without producing dangerous shock. In the writer's experience shock, apart from hemorrhage, has been responsible for a mortality of less than one-fifth of 1 per cent. in patients subjected to deliberate operative procedures, and not over 2 per cent. of major operative cases have suffered from shock of a degree sufficient to cause the least anxiety as to the outcome. In order to get the best results it is necessary for the surgeon not only to know the usual causes of shock and how to, as far as possible, avoid them, but he should in each individual case in which shock is at all liable to be an important factor make a careful estimate of the shock risk and plan every detail of the operation accordingly.

Patients differ greatly as regards susceptibility to shock, the special dangers occurring largely in those handicapped by readily recognizable impairments which make them especially susceptible to the action of shock-producing causes. Different regions and organs of the body also show different degrees of susceptibility.

Temperament.—Experimental investigations have shown that noxious impulses transmitted through the nervous system are the immediate cause of shock and practical experience has shown that the high-strung, acutely sensitive individual is more susceptible to shock than is the phlegmatic type of patient.

Frightened patients are particularly bad shock risks, and most students of this subject believe that fright itself is an important element in the production of shock.

Previous Nerve Exhaustion.—Many look on shock as essentially a phase of nerve exhaustion and certainly patients who from overwork or worry have exhausted their reserve of nervous energy are more susceptible to shock than is the man or woman who has lived a rational life keeping each bodily function up to a normal standard of activity. Crile says that the worst risk is probably the overworked surgeon, about fifty years of age. Work short of actual exhaustion is, however, not a handicap, because the industrious and those who have by their daily life accustomed themselves to overcoming the lesser trials of every-day existence are, other things being equal, far better shock risks than are the idle luxurious type of loafers. The hard working laundress is, as a rule, a better shock risk than is her idle employer.

Age.—Surgeons are generally agreed that children are more susceptible to shock than adults yet this increased susceptibility is very difficult to estimate. It has been said that could the infant be operated on in its own ratio, that is to say, by Lilliputian surgeons, using infantile instruments, etc., and exposing only proportionate areas to heat, cold and traumatism the results might not be disproportionate to those obtained in the adult. This is impossible. Therefore, from the practical standpoint, the infant and child require a special estimate of the shock risk and very frequently the institution of special precautions to guard against the danger of shock.

Old people may not be particularly susceptible to shock as measured by the ordinary standards of pulse and blood-pressure, yet in them shock is relatively much more dangerous than in the young or middle-aged because of their lack of "come back" or power to recover from what in individuals with normal hearts and bloodvessels would amount to only temporary disability. Serious shock may come on during operations on the aged without its being recognized either by the surgeon or the anesthetist. This is partly because it is difficult to recognize pulse quality in the presence of arteriosclerosis, partly because the increase in pulse frequently does not keep pace with the degree of shock in the aged as it does in the young, and partly because of a failure to realize that a blood-pressure of 100 to 110 mm. is a serious matter in a patient whose "normal" pressure is 160 to 170 mm. or over, while in a younger individual a fall in blood-pressure to 100 mm. or even lower would be of little relative importance.

Sepsis.—Patients suffering from any form of sepsis should be looked upon as having an increased susceptibility to shock, and yet in these cases it is probable that the postoperative symptoms often ascribed to shock are really the result of increased toxin absorption incident to manipulating infected tissues and the breaking down of natural barriers against absorption.

The collapse which frequently follows the curettage of a septic uterus is not shock but toxemia. Likewise the grave symptoms which formerly followed extensive intra-abdominal manipulations in the presence of acute infection were in part due to shock and in part to sudden toxin absorption.

Recent Severe Illness.—A typical example of increased susceptibility to shock is seen in patients who have only partially recovered from a severe illness and who are operated "before they have had time to regain their strength."

The patient, who lying quietly in bed, has a normal temperature and normal pulse of fair volume but who has only recently recovered from the acute stage of a serious gall-bladder or renal or other form of infection is a handicapped risk as regards shock—a risk relatively safe within certain limits but a very bad risk when these limits are exceeded by a careless or too radical surgeon.

In the writer's personal experience instances of unlooked for shock have been confined largely to this class of cases, among which may be mentioned secondary operations for osteomyelitis, nephrectomies and operations for pelvic infections in which neither the operative manipulations nor the hemorrhage were sufficient to account for the degree of shock produced. The possibility of the shock-like symptoms being due to embolism should always be considered in this class of cases.

Cachexia.—One of the most serious of the predisposing causes to shock is that little understood state of metabolic perversion occurring in the course of malignant disease which is known under the general term cachexia. The vital impairment in this class of patients is difficult to estimate. Operations in them are usually of necessity severe. Increased susceptibility to shock is the rule, but the most important factor in connection with the prognosis in these cases is the fact that, while they may exhibit only a relatively slight increased susceptibility to shock, their power to react and recover is often almost *nil.* Like the senile individuals, only often to a greater extent, they have no "come back."

Brain Surgery.—First among the operations especially liable to be accompanied by shock are those involving portions of the central nervous system. Even the jarring, incident to chiselling through the skull may produce shock. Sponging of the exposed meninges is another cause. Horsley,[1] Cushing[2] and others have pointed out the dangers incident to increased intracranial pressure.

Laryngeal Operations.—In such operations as intubations, laryngotomies, laryngectomies, intralaryngeal operations of all sorts, operators have reported instances of sudden collapse or death. According to Crile, this is due to reflex inhibition of the heart and of the respiration from mechanical stimulation of some part of the superior laryngeal nerve and may be wholly obviated by previously administering a physiological dose of atropin or by applying a local anesthetic to the nerve endings in the laryngeal mucosa or by injecting the trunk of the nerve with novocain.

Intrathoracic Operations.—Sudden changes in intrathoracic pressure such as occur on opening empyemata, or to an even greater extent when the normal pleural cavity is opened, are always liable to be accompanied by serious shock.

Blake[3] has summed up the experience gained in the War as follows: "One of the most striking observations was in regard to wounds opening the pleural cavity—the so-called sucking wounds. It was noticed that with such a wound a man got along fairly well for a short time and then rapidly went into shock and died. The reason was, as we have seen in the explanation of shock, a lack of oxidation due to inadequacy of respiration. If the admission of air through the wound were stopped, these cases did as well as those with non-sucking wounds. It became the rule, therefore, to close such wounds as soon as possible, even if they were only provisionally sewed together and had to be operated on and reclosed later. It was found that if shock could thus be prevented the patient could subsequently withstand a formal operation in the course of which the wound of the chest wall could be excised and enlarged, the lung withdrawn if necessary, the wounds in the latter also excised and sutured, and the chest finally closed. Closure of the chest, if only for a day or two to enable the vital functions to become readjusted, was found imperative."

Abdominal Operations.—"In abdominal operations the amount of shock depends in direct ratio upon the trauma and exposure. This

[1] British Med. Jour., 1890, iv, 1286.
[2] Bull. Johns Hopkins Hosp., 1901, i, ii, 290.
[3] The Influence of the War upon the Development of Surgery, vol. lxix, May, 1919, p 459.

territory bears a rich supply of vasomotor nerves, and the effect of a given operation upon the vasomotor center is the sum of the exposure to the air and the intensity and number of mechanical contacts with the abundant nerve supply of this territory." (Crile.)

Operations in the region of the diaphragm, the common bile duct, the pancreas and all operations involving extensive traumatism of the mesentery (intestinal resections) are especially shock-producing. Operations below the pelvic brim are, as a rule, less shock-producing than those in the upper abdomen.

Operations on the Extremities.—In operations upon the extremities shock may be almost entirely avoided if care be taken to prevent hemorrhage and to either avoid injuring the larger nerve trunks or to block the nerves by intraneural injections of novocain. Nerve blocking should be employed in all operations upon the extremities likely to be accompanied by shock.

Wound Infection.—The whole science of modern surgery has developed around the fact that except in war surgery it lies within the power of the surgeon to prevent wound infection in all but a very small minority of the cases he is called upon to treat. In general it may be said that the prognosis as regards infection is, in the individual patient, what the surgeon himself makes it, and yet experience has always shown that no surgeon has been able to entirely eliminate this complication from his work.

Infection always increases the postoperative morbidity and prolongs the period of convalescence. Not infrequently it serves to defeat the purpose of the operation and occasionally an accidental infection results in the death of the patient. Most of the postoperative complications leading to more or less serious permanent disability are the result of infection.

Statistics dealing with the frequency of wound infections have for the most part been published with the idea of proving the superiority of some particular aseptic or antiseptic technic, yet when we attempt to compile and compare these results it is evident that the averages as reported for the different methods are very nearly the same provided the character of the operative work is of approximately the same nature.

Beckman[1] reports 1.9 per cent. of infections in a series of 5835 operations and 1.7 per cent. of infections in another series of 6825[2] operations performed at the Mayo Clinic. This (2 per cent.) is about the average frequency as reported from various sources.

Operations on the Extremities.—This field of surgery offers ideal opportunities for the carrying out of an approved technic, and orthopædic surgeons have abundantly demonstrated that in civil practice the incidence of infection following operations on the extremities is almost entirely under the control of the operator; also, that there is no special liability to infection in operations involving bones and joints

[1] Collected Papers by the Staff of St. Mary's Hospital, 1912, pp. 738–747.
[2] Ibid., 1913, pp. 776–782.

provided the manipulations do not endanger the vitality of the tissue. When infections do occur, however, as the result of operations involving bones or joints the prognosis as regards the effect of the complication on the outcome of the operation is usually much more serious than after operations limited to the soft tissues.

An exception to the above rule regarding the relative freedom from infections in operations on the extremities is apparently encountered in the operative treatment of fractures. The peculiar liability of compound fractures to serious infection and the disastrous consequences of the same has been recognized since the earliest times. Within recent years this has been again emphasized in connection with the open treatment of fractures. In this field of surgery, especially when buried metal splints are employed, even the slightest grades of infection, such as would be scarcely demonstrable in abdominal surgery, are fraught with the most serious consequences. Lane has demonstrated that infection can be avoided but the standard necessary for success is entirely different from that ordinarily attained by the average general surgeon, and failures in this field of surgery have been frequent and serious.

Operations of the Head, Face and Neck.—The face and scalp are particularly resistant to infection. Scalp wounds, even those the result of accident, seldom become infected. Operative wounds in the region of the mouth, even though they be made through fields impossible of sterilization, heal by first intention in the great majority of cases.

Although the technical difficulties of maintaining absolute asepsis during operations upon the neck are considerable, infection in this region is rarely encountered and the occasional infection which does occur is seldom of much importance. Beckman reports only 26 infections in 2785 operations for goiter, or less than 1 per cent., and none of these resulted seriously.

The Breast.—Practically all surgeons report a very low incidence of infections following amputation of the breast. The Halstead type of breast amputation exposes a large surface to possible infection, the field is frequently difficult of sterilization and closure of the skin defect often necessitates tension on the sutures There may be some sloughing of the skin but noteworthy infection is seldom encountered.

Hernia.—Beckman reports 31 infections in the course of 623 operations for inguinal hernia (4.9 per cent.). This proportion seems high and yet it is approximately the average as reported by other surgeons. Hilgenreiner[1] has reported 4.2 per cent. infections in 1000 operations for hernia performed between 1901 and 1910. Sertoli,[2] from Ceci's Clinic, reported that in 1509 operations for non-strangulated hernia, the wound suppurated in 90, or 6 per cent. A few have reported better results but many more have admitted an even higher percentage of infection.

[1] Beitr. z. klin. Chir., December, 1910.
[2] Arch. f. klin. Chir., 1909, No. 2.

Ventral and umbilical hernias apparently exhibit about the same tendency to infection as do inguinal hernias. Femoral hernias are, on the other hand, rarely accompanied by infection.

Whether the liability to infection in hernias be due to the difficulty in sterilizing and dressing the field, or to the suture tension necessary to close the defects, or to the necessity of using slowly absorbable suture material, the fact should always be borne in mind that hernia operations are for some reason particularly liable to infection.

Gynecological Operations.—Laparotomies for tubal and ovarian conditions, shortening the round ligaments and other minor gynecological conditions are seldom accompanied by infection. Subtotal hysterectomy adds a slight risk possibly due to increased traumatism and possibly due to opening the cavity of the uterus. On the other hand, total abdominal hysterectomy yields a large percentage of infections (7 per cent. Beckman), due to the fact that the vagina often harbors virulent organisms in cases requiring total hysterectomy, while at the same time unavoidable trauma incident to the operation leaves a field susceptible to bacterial invasion.

In spite of the fact that it is impossible to secure an actually sterile field in vaginal operations, infections interfering with the results of operations on the cervix or perineum are seldom encountered, although perfect primary union in the sense used when speaking of abdominal wounds is frequently not obtained. Formerly the writer used great care in sterilizing the vagina but in a certain percentage of cases it was apparent that the normal harmless bacteria inhabiting this region were removed only to have it reoccupied soon after the operation by new species toward which the body had not had an opportunity to develop an immunity. During the past six years I have made no effort to sterilize the vagina other than a simple cleansing with soap and water, and I am certain that the healing in vaginal cases has been far better than when we disturbed the truce existing between the body and the normal vaginal flora.

Intestinal Tract.—The danger of infection by intestinal bacteria in all operations on the intestinal tract is self-evident. Under ordinary conditions in otherwise clean laparotomies the incidental removal of the appendix seems to approximately double the liability to infection. In this connection it is worthy of note that whereas most surgeons use great care in handling the stump of the appendix itself most of them fail to appreciate the fact that the needle and suture used in inverting the stump is usually promptly infected by passing it through all coats of the cecum, and that the suture and the objects coming in contact with it should thereafter be looked upon as infected. With proper attention to this detail, we believe that the extra risk, due to appendectomy in otherwise clean cases, can be eliminated.

Beckman reports 5.7 per cent. of infections in 750 operations on the stomach, and according to data from other sources from 5 to 10 per cent. would seem to be a fair average. These infections in stomach cases rarely result in fatal complications, but they do frequently result in ventral hernia.

Operations on the large bowel are accompanied by some infection in a large percentage of cases, and in the surgery of the large intestine more frequently than in any other branch of abdominal surgery, infection is liable to lead to fatal complications.

The Peritoneum.—The ability of the peritoneum to resist infection is not surpassed by any other tissue in the body. In estimating the possibilities of a peritoneal infection occurring as the result of an operation, laparotomies may be divided into three classes: (1) Those cases in which the operation is performed for a condition other than an active infection, and in which no infected cavities are invaded during the course of the operation. In this group are included hernia operations, many gynecological, a certain proportion of gall-bladder operations and other miscellaneous laparotomies. (2) Operations in which no active infection is present but in which infected or possibly infected cavities are invaded during the course of the operation. Appendectomies, hysterectomies, operations upon the gastro-intestinal tract and some of the operations on the biliary and urinary tracts should be included in this group. (3) Operations undertaken for the relief of active intraperitoneal infections.

In the first group serious accidental infection of the peritoneum is one of the rarest accidents in surgery. In the second group noteworthy peritoneal infection is only very rarely encountered in simple appendectomies, gall-bladder operations or hysterectomies. With good technic it is also rare after operations on the stomach and upper intestinal tract. On the other hand, operations involving resection of portions of the large intestine are frequently accompanied by serious peritoneal infection. In the third group modern technic aiming to protect and assist the peritoneum in its fight against the already existing infection has to a considerable extent lessened the danger of the infection being spread as the result of the operation. In these cases the danger is greatest during the height of the infection and decreases rapidly after the subsidence of the acute stage of the inflammatory process, so that in subacute and chronic cases abscesses may be opened and drained through incisions opening into the general peritoneal cavity with surprisingly little danger of extending the area of infection.

Except after operations on the large intestine cases of postoperative general peritonitis, such as were rather frequently encountered by the pioneers in abdominal surgery, are now almost always due to gross accidents, such as overlooking rents or fistulous openings in the intestines, faulty intestinal suturing or improperly placed drainage, allowing pus, bile or urine to escape directly into the peritoneal cavity.

Incisions Made for the Purpose of Treating Infections.—In operations undertaken for the treatment of acute inflammatory conditions the incisions are necessarily exposed to infection, and the question of the extension of the infection to such incisions is of considerable practical importance. In general it may be said that if the primary focus of infection is thoroughly drained, that portion of the incision which is sutured at the close of the operation will heal by primary union.

In the writer's experience abdominal drainage cases operated during the acute stages of an intraperitoneal infection have yielded a much higher proportion of wound infections than have cases operated after the subsidence of the acute stage, even though pus was encountered at the time of the operation. This is probably due chiefly to the fact that in the later operations an acquired immunity has been developed against the organisms responsible for the infection. At a still later period the pus may be sterile or the organisms may have lost their virulence.

A considerable proportion of the more troublesome wound infections has been in patients operated for acute intraperitoneal lesions in which the abdomen was closed without drainage, or in abscess cases in which the drainage was carried through a lateral stab wound without providing for adequate drainage of the principal incision. In the first group the peritoneum has had no difficulty in overcoming the infection which in less resistant tissues has been sufficient to break down the abdominal incision. In the second class of cases the closure of the chief incision with the use of a lateral stab wound for drainage has not only been unsatisfactory as regards healing but has resulted in more ventral hernias than would probably have occurred had the drainage been brought out through one end of the original incision because without drainage the chief incision has broken down.

Accidental Wounds.—Infection in wounds of the industrial accident type is dependent upon a number of factors. Cuts and simple lacerations are much less liable to become infected than are open wounds accompanied by considerable crushing of the soft parts. The character of the surroundings in which the accident happens is also a very important factor. The grease and dirt of the machine shop is seldom the habitat of virulent, pathogenic organisms. On the other hand, street dirt usually contains organisms capable of causing infection. Ambulances, doctors' offices and dispensaries are always dangerous localities, and before an accident case is allowed to enter any one of these highly infected regions open wounds should always be covered with a sterile first-aid dressing.

The possibility of effectually sterilizing the field of traumatism after an accident is a question still open to discussion. Some surgeons believe in very vigorous use of mechanical and antiseptic methods of cleansing the wound. Others believe that the really essential point is to preserve the vitality of the tissues and that whatever is done in the way of a toilet of the wound the tissues should not be subjected to further mechanical or chemical traumatism. The success attending the use of tincture of iodin in these cases is probably dependent largely upon its simplicity and relative harmlessness as compared with more complicated methods formerly employed.

In general it may be said that a surprisingly large percentage of accidental wounds heal without suppuration and that in the absence of pathogenic germs gaining access to the wound *after* the patients come under treatment, serious infections are but seldom encountered.

War Wounds.—One of the lessons of the late World War was the fact that civil experience and war experience are entirely different as regards the frequency of wound infections. The great liability of infection and the factors governing the same will be described in other chapters of this book.

Postoperative Pulmonary Complications.—Postoperative pulmonary complications may be classified in five groups (Beckman):

1. **Acute Postoperative Congestion of the Lungs.**—This condition is characterized by an excess of secretion in the air passages. It is usually most noticeable immediately after the operation and subsides in a few hours. As a rule, it has little or no effect on the prognosis.

2. **Pleurisy.**—This is a relatively frequent minor complication. The symptoms last from a few days to a week, rarely longer. Serious results are very rarely observed.

3. **Bronchitis.**—This is the most frequent of the postoperative pulmonary complications. The acute symptoms usually subside in a few days and serious results are rarely encountered, although the discomfort produced by the coughing is often considerable. Occasionally the extra strain placed on the suture line in abdominal cases is the cause of a subsequent ventral hernia.

4. **Bronchopneumonia** and 5, **Lobar Pneumonia.**—Pneumonia is one of the most serious of the postoperative complications. Clinically it is often difficult to separate the two forms of the disease, and in most of the statistical studies dealing with pneumonia as a postoperative complication no attempt has been made to separate them. The frequency of this complication varies in statistics from different sources due probably in a large measure to the different character of the material analyzed in compiling the statistics.

In America postoperative pneumonia is a rare complication. Thus, Beckman,[1] Anders[2] and Miller[3] report 37,132 operations followed by 103 cases of pneumonia, or 1 case of pneumonia for each 360 cases operated. Beckman and Anders report 24 deaths from pneumonia following 30,132 operations, or 1 death for each 1255 cases operated.

These results are in sharp contrast to the often quoted statistics of Mikulicz,[4] Henle,[5] Gibele[6] and Czerny,[7] which may be summarized as follows:

Mikulicz	1278	operations	with	110	pneumonias.
Henle	1987	"	"	145	"
Gebele	1196	"	"	54	"
Czerny	1300	"	"	52	"

[1] Northwestern Lancet, May 15, 1911; Ann. Surg., 1913, vii, 718–729; Collected Papers by the Staff of St. Mary's Hospital, 1913, pp. 784–785.

[2] University Med. Mag., Philadelphia, 1897–1898, x, 641–666.

[3] Kelly and Noble's Gyn. and Abd. Surg., 1910, ii, 35.

[4] Pneumonie, Verhand. d. XXX Kongr. der Deutsch. Gesellsch. f. chir. Centralbl. f. Chir., 1901, No. 29, p. 16.

[5] Ueber Pneumonie und Laparotomie, Arch. f. klin. Chir., xliv, Heft 2.

[6] Beitr. z. klin. Chir., xliii, Heft 2, 251–318.

[7] Cited by Miller in Kelly and Noble, loc. cit.

The great majority of the above operations were laparotomies and Continental surgeons only a few years ago insisted that pneumonia was to be expected after laparotomy in about 5 per cent. of the cases. This figure is certainly from five to ten times greater than the average American frequency following abdominal operations. Robb and Dittrick,[1] after 1007 abdominal operations, found only 3 cases of pneumonia, while Mallett,[2] after 1700 laparotomies found 7 cases of pneumonia.

The exact relationship between the anesthetic and the pulmonary group of postoperative complications has never been definitely determined. The terms "ether pneumonia" and "ether bronchitis" are very frequently used. Yet before the discovery of anesthesia, lung complications caused a high mortality after operation, and modern statistics dealing with the frequency of these diseases fail to show any clearly defined relationship between the anesthesia and the pulmonary complication.

The figures reported by Mikulicz[3] are typical. He states that at the Breslau Clinic in 1005 laparotomies and operations for strumous affections under general anesthesia there was a pneumonic morbidity of 7.5 per cent. with a mortality of 3.4 per cent. In 273 cases operated under local anesthesia (Schleichs's method) there was a morbidity of 12.8 per cent. and a mortality of 4.8 per cent. due to pneumonia. These results do show that great care should be exercised in placing the blame on the anesthetic, yet local anesthesia was used in a considerable proportion of these 273 cases because of the known liability of the individual cases selected to pneumonia if operated under general anesthesia. The pulmonary mortality might have been considerably higher under general anesthesia. I know of no trustworthy statistics on this subject comprising large groups of similar cases operated under different methods of anesthesia.

As a matter of fact the incidence of postoperative pneumonia depends very largely upon the age and general condition of the patient and the character of the disease for which the patient is operated. Fatal pneumonia may follow the simplest operation on a patient in the prime of life and apparently in the best of health, but such accidents are extremely rare. Past middle age the danger of pneumonia increases directly with the age of the patient until in the very old the danger becomes so great as to be one of the chief causes of surgical mortality. Likewise in the severely septic and the debilitated from any cause, particularly alcoholism, the dangers of pneumonia are greatly increased. Operations on the stomach and gall-bladder are said to be specially liable to be followed by pulmonary complications.

The inspiration of material into the lungs during an operation greatly increases the danger of bronchopneumonia.

[1] Cited by Miller, loc. cit.

[2] Am. Jour. Obst., April, 1905, p. 516.

[3] Pneumonie, Verhand. d. XXX Kongr. der Deutsch. Gesellsch f. Chir. Centralbl. f. Chir., 1901, No. 29, p. 16.

TABLE IV.—SHOWING RELATIVE FREQUENCY OF THE DIFFERENT PULMONARY COMPLICATIONS.

	Bronchitis.	Pneumonia.	Pleurisy.
Miller	18	17	16
Robb and Dittrick	18	3	9
Armstrong[1]	19	20	5
Beckman	72	56	55
	127	96	85

Embolism.—With the gradual reduction of operative mortality due to other causes, embolism has assumed a place of constantly increasing relative importance, until today it is one of the important causes of surgical mortality.

The great majority of cases of fatal postoperative embolism are due to the sudden plugging of a vessel of the lung (pulmonary embolism) with a clot originating in the field of operation or femoral vein. Occasionally the clot may originate in a vessel other than the femoral at some distance from the field of operation or in the heart itself. Occasionally the clot may lodge in the brain (cerebral embolism) or in the heart (cardiac or coronary embolism). Embolism involving other organs notably the kidneys, spleen or intestines is frequently observed at autopsy but is seldom recognized clinically. The smaller pulmonary emboli, such as are so frequently found at autopsy, are probably responsible for many cases of so-called pleurisy. Fat embolism and air embolism will be discussed under separate heads.

Wilson[2] calls attention to the following general considerations concerning the subject of postoperative embolism:

"1. Following operation, particularly on the bloodvessels, alimentary canal and genito-urinary organs (both male and female), from 1 to 2 per cent. of all cases give more or less distinct clinical evidence of emboli, above 70 per cent. of which are in the lungs.

"2. As nearly as can be observed from the incomplete and necessarily inaccurate data at hand, about 10 per cent. of postoperative emboli which give clinical symptoms of diagnostic significance cause sudden death.

"3. Where postmortems are made on cases of fatal postoperative embolism, the source of the emboli can be definitely determined as venous thrombosis in about 80 per cent. of the cases, as cardiac thrombosis in 10 per cent. of the cases, while 10 per cent. are scattering or undeterminable.

"4. Though there must be more or less formation of venous thrombi at the site of every extensive surgical operation, yet it is probable that the long, loosely-formed thrombi from the medium-sized veins are those chiefly concerned in embolism, and especially in fatal embolism.

[1] Lung Complications after Operations with Anesthesia, British Med. Jour., 1906, i, 1141.

[2] Fatal Postoperative Embolism, Ann. Surg., December, 1912.

"5. When large, loose thrombi are once formed in a resting patient, any unusual exertion or change of position may cause a dislocation of large masses which become dangerous emboli."

The mortality from embolism, based on the 63,573 operations reported by Wilson is 0.07 of 1 per cent., or 1 death in every 1352 operations. When the cases are grouped according to the anatomical regions on which the preceding operation was done, they are found to be as follows:

After 1372 operations on bloodvessels, 2 deaths, or 0.14 of 1 per cent.

After 3266 operations on the thyroid, 2 deaths, or 0.06 of 1 per cent.

After 2281 operations on the mouth, 1 death, or 0.05 of 1 per cent.

After 2391 operations on the stomach or duodenum, 3 deaths, or 0.12 of 1 per cent.

After 4597 operations on the gall-bladder, 9 deaths, or 0.19 of 1 per cent.

After 389 operations on the small intestine, 1 death, or 0.26 of 1 per cent.

After 9908 operations on the appendix, 4 deaths, or 0.04 of 1 per cent.

After 2530 operations on the colon and rectum, 5 deaths, or 0.20 of 1 per cent.

After 4501 operations on hernia, 5 deaths, or 0.11 of 1 per cent.

After 900 operations on the kidney, 1 death, or 0.11 of 1 per cent.

After 601 operations on the prostate, 4 deaths, or 0.66 of 1 per cent.

After 7993 operations on the uterus, tubes and ovaries, 10 deaths, or 0.13 of 1 per cent.

After 1346 operations on the breast, no deaths.

After 449 vaginal hysterectomies, no deaths.

After 1712 abdominal hysterectomies, 5 deaths, or 0.29 of 1 per cent.

These figures in themselves fail to show any particular liability to embolism in any special field of operative work except possibly operations on the prostate and supravaginal hysterectomy. In this connection it has long been known that cases of prostatectomy and operations for uterine myomata are especially liable to be followed by pulmonary embolism.

The frequency of fatal embolism as given by Wilson is, for the most part, lower than that given by others who have studied the subject. While the material analyzed is not strictly comparable, the discrepancies in the data from different sources is best indicated in the following manner:

Wilson, 63,573 operations, 47 deaths from emboli.

Oppenheim,[1] 6871 operations, 23 deaths from emboli.

Wilson, 9908 operations on appendix, 4 deaths from emboli.

Howard,[2] 3774 operations on appendix, 8 cases of pulmonary embolism.

[1] Berl. klin. Wchnschr., 1902.

[2] Phlebitis and Thrombosis, 1906, p. 41.

The following figures show the recognized frequency of embolism as reported from different sources:

	Per cent.
Gebele,[1] 1196 laparotomies, embolism in	1.17
Lowen,[1] 1203 laparotomies, embolism in	0.75
Wolff,[1] 1806 operations, embolism in	0.49
Bibergeil,[1] 3909 laparotomies, embolism in	0.30
Albanus,[1] 1140 laparotomies, embolism in	0.20
Sorrenburg,[2] 2000 appendix operations, embolism in	5.30
Oppenheim,[3] 6871 operations, embolism in	0.82
Krönig,[4] 391 myoma operations, embolism in	0.50
Burkhardt,[4] 236 myoma operations, embolism in	5.00
Frieberg Klinic,[4] 2265 laparotomies, embolism in (deaths)	0.10
v. Winczel,[5] 836 laparotomies, embolism in	1.20
Stanton,[6] 1573 operations, embolism in (deaths)	0.13
Sertoli,[7] 1543 herniotomies, embolism in (deaths)	0.20

Fat Embolism (*Traumatic Lipemia*).—Fat embolism is a possible complication after all bone injuries and after orthopedic operations and manipulations. In the past it has been looked upon as a pathological curiosity, and yet the observations of Warthin[8] and others would seem to indicate that a fairly large proportion of the deaths following traumatisms and commonly ascribed to such causes as shock, heart failure, acute cardiac dilatation, cerebral hemorrhage, pneumonia, sepsis, insanity, alcoholism, etc., are really examples of fat embolism. Out of 12 cases of fatal traumatic lipemia autopsied by Warthin the real cause of death had been suspected in only 1 case, and yet all had occurred in the services of clinicians of the highest standing.

Bissell[9] in a review of clinical and experimental data from the Mayo Clinic has shown that fat embolism is one of the really important causes of serious postoperative complications often closely simulating simple shock.

Air Embolism.—This accident is so rare as to have practically no effect on prognosis. Nevertheless, its possibility should always be borne in mind when operating in regions where there may be a negative venous blood-pressure during inspiration.

With the patient lying flat on the operating table the region of danger is practically limited to the subclavian and the lower third of the jugular veins. With the head elevated to the semi-sitting posture the danger in head and neck operations is considerably increased. In this position air embolism may follow opening one of the cranial sinuses as well as any of the large venous trunks of the neck.

[1] Quoted by Beneke, Die Embolie, in Krehl and Morehead, Handbuch der Allgemeinen Pathologie, 1913, Pt. 2, vol. ii.

[2] Arch. f. klin. Chir., 1902, vol. lxviii. [3] Berl. klin. Wchnschr., 1902.

[4] In Aschoff and others, Beitr. zur Thrombosfrage, Leipzig, 1912.

[5] Thrombose und Embolie nach Gynäkologischen Oper., Beitr. z. klin. Chir., 1913, lxxxiv, 37–46.

[6] Albany Med. Ann., August, 1914. [7] Arch. f. klin. Chir., 1909, No. 2.

[8] Traumatic Lipemia and Fatty Embolism, International Clinics, 1913, 23d series, iv, 171–227.

[9] Pulmonary Fat Embolism, a Frequent Cause of Postoperative Surgical Shock. Collected papers of the Mayo Clinic, ix, 1917, 535–559.

With the patient in the Trendelenburg position air embolism may follow gynecological operations, but this is very rare.

Of 33 cases collected by Cauty,[1] in 1876, the point of entrance was in the external jugular nine times, in the axillary eight times, in the internal jugular five times, in the subscapular three times, in the facial occipital, anterior jugular and anterior thoracic, each twice. The accident occurs with the greatest frequency after operations for the removal of tumors from the neck and axilla.

Cases have been reported from the use of air dilatation in the bladder, uterus and the knee-joint.

The recent extensive use of intravenous medication has yielded an occasional fatality from air embolism.

Embolism Due to Miscellaneous Causes.—The use of paraffin injections to correct nasal deformities has resulted in a number of reported cases of paraffin embolism. The use of Beck's paste in the treatment of sinuses has also been followed by symptoms of embolism. Intramuscular injections of oily suspensions of mercury and other substances has occasionally resulted in embolism.

Phlebitis.—Its comparative frequency and distressing after-results combine to make phlebitis one of the most troublesome of the postoperative complications. It is also met with after labor, occasionally after non-operative traumas and after certain of the infectious diseases, notably typhoid fever.

In 232 cases collected by Cordier[2] the vessels involved were as follows:

The left saphenous or femoral vein affected	213
Both right and left veins affected	8
The right veins alone affected	11
The proximal part of vein first affected	182
The distal part of vein first affected	36

Schenek[3] reports 566 cases following 49,161 operations (1.15 per cent.) which gives a general idea of its frequency.

In surgical work it occurs most frequently after laparotomies and hernia operations, and only rarely after extraperitoneal operations as is shown by the following data compiled by the writer.

	Operations.	Phlebitis.	Per cent.
Laparotomies	17,090	280	1.63
Herniotomies	1,669	13	0.8
Miscellaneous extraperitoneal operations	6,121	8	0.13

All authors agree that it is several times more frequent following operations for myoma uteri than any other laparotomies.

The 232 cases collected by Cordier occurred after the following operations the number of times stated:

[1] Arch. d. Physiol., 1876.

[2] Phlebitis Following Abdominal and Pelvic Operations, Jour. Am. Med. Assn., 1905, xlv, 1792–1797.

[3] Thrombosis and Embolism Following Operations and Childbirth, Tr. Am. Gynec. Soc., 1913, xxxviii, 295–311.

Hysterectomy for fibroids—so-called aseptic cases	69
Abdominal and pelvic operations—character not stated	56
Appendectomy—mostly so-called aseptic cases	27
Oöphorectomy—cystic, cirrhotic, etc.	16
Pelvic operations—character not stated	9
Vaginal hysterectomy for cancer	9
Nephrorrhaphy	9
Vaginal operations—character not stated	8
Suspension of uterus	7
Cholecystotomy	4
Hernia	4
Ectopic pregnancy	4
Alexander's operation	3
Splenectomy	1

From various sources the writer has compiled the following figures which give an approximate indication of the relative frequency of phlebitis after several frequently performed operations:

	Operations.	Thrombosis.	Per cent.
Operations for myoma uteri	3,416	108	3.1
Intraperitoneal pelvic operations other than for myoma	1,369	15	1.1
Appendectomy	5,959	77	1.6
Operations on gall-bladder	821	4	0.46
Operations on stomach and intestines	689	2	0.3
Operations for inguinal hernia	1,323	9	0.67
Operations for ventral hernia	243	4	1.6
Operations for femoral hernia	103	0	0.0
Labor	96,000	381	0.4

Ultimate Prognosis.—There is very little data available concerning the ultimate prognosis of crural thrombosis. Schenek studied the late histories of 29 patients, 8 of them had symptoms for about four months and subsequently no trouble; 2 had some difficulty in walking for about twelve months and then completely recovered; 19 never fully recovered, being troubled with swelling and with more or less pain after being on their feet more than usual. On the basis of these cases, he assumes that about 65 per cent. of the patients never fully recover, and that if complete restoration is to follow it will come before the end of the first year, by which time the collateral circulation is as completely established as it ever will be.

Without quoting definite figures other surgeons express essentially the same opinion concerning the ultimate effects of phlebitis.

There is considerable divergence of opinion concerning the frequency of embolism in cases with phlebitis. Among the 233 cases studied by Cordier there were 6 cases with pulmonary symptoms possibly referable to emboli and three cases of sudden death. The same operations which are most frequently followed by phlebitis are also the ones most frequently followed by embolism although the two complications may not occur in the same patients. Clinics reporting a high frequency of phlebitis also have a high frequency of embolism, showing that there is a common etiological factor for the two. It is worthy of note that, in spite of a general belief in the infectious origin of thrombosis, most cases occur following so-called aseptic operations, and recent investigations—Krönig, Aschoff, v. Wenszel—all agree that blood stasis is probably a more important etiological factor in phlebitis than is infection.

Peritoneal Adhesions.—The real importance of adhesions as a cause of distressing symptoms following laparotomies is difficult to estimate. Probably the majority of abdominal surgeons consider them as among the greatest evils associated with their work. Many believe that they are the principle cause of invalidism following laparotomies. On the other hand, it is very easy to overestimate the importance of postoperative adhesions. Their presence is by no means confined to the unsuccessful cases and their almost constant presence after laparotomies makes them a most convenient excuse for the surgeon seeking to justify a poor result.

In this connection it is a fact worth noting that patients operated for definite pathological conditions of a character constantly associated with adhesions, such as appendicitis with abscess, pelvic inflammatory conditions and acute cholecystitis, seldom complain of serious symptoms due to this cause, while the neurasthenic operated for what amounts to practically nothing is more than likely to be greatly troubled with "adhesions." An extensive study of the causes of poor end-results in abdominal surgery seems to indicate that while adhesions are frequently of great importance they are altogether too frequently used as a refuge behind which the surgeon hides his mistakes in diagnosis and surgical judgment.

Experience has taught that although the factors underlying their formation are fairly well known, those determining the *persistence* of adhesions are as yet very imperfectly understood. The average case of severe pelvic or appendiceal peritonitis has most extensive adhesions during and immediately after the attack yet a few months later there may be scarcely any to be discovered anywhere in the abdomen. On the other hand, every surgeon of experience knows that after operations which were performed for non-inflammatory conditions, where every form of traumatism or infection could be ruled out, where no packings or drains were used, where no reaction of any kind was observed, in short in cases where the conditions were apparently ideal as regards their avoidance, very extensive adhesions not only develop but *persist* in spite of every effort to get rid of them.

In general it may be said that the immediate formation of peritoneal adhesions after operation is in direct proportion to the amount of sepsis, the raw areas left by operative procedures, the injury to peritoneal surfaces resulting from contact with gauze pads and drains, the minor traumatisms incident to operative manipulations and the injury due to chemicals and exposure to drying. The primary fibrinous variety which form over practically all injured peritoneal surfaces immediately after an operation are an essential part of the repair process which makes intra-abdominal surgery possible. In so far as they represent repair of unnecessary damage they are to be avoided, but in themselves they have little influence on the outcome of the operation. Most of these adhesions disappear by resolution and the majority of those which undergo organization are soon reabsorbed. The trouble is that all of them may not be reabsorbed and that in the present state of our knowledge it is almost impossible to predict which will be permanent and which will not. Very extensive experimental work designed to determine the laws governing their formation and persistence has served to emphasize the fact that results even under experimental conditions are extremely variable. The literature and experimental data has been reviewed by Richardson[1] to whom we are indebted for many of the references quoted below.

In estimating the possibility of troublesome adhesions in the individual patient it is necessary to consider each of the several possible causes of adhesions, such as blood clots and free blood in the peritoneum, sutures, ligatures, etc., which may be present in the case at hand.

Blood Clots and Free Blood in Peritoneum.—The relation of free blood in the peritoneal cavity to adhesion formation is a question about which a final verdict has not yet been given. Penzoldt[2] published, in 1876, the results of a very elaborate experimental research into the fate of large amounts of blood in the peritoneal cavity, showing that it is absorbed. Wegner,[3] in 1877, and later Vogel,[4] observed the same thing experimentally. v. Dembowski,[5] in 1888, reported the results of a large number of carefully executed experiments on adhesion formation in the peritoneal cavity, and concluded with reference to blood clots, that they do not provoke adhesions. Fromme[6] reported a few years ago the results of very elaborate and painstaking experiments on rabbits designed to test (1) the effect of blood alone, and with serous defects in the peritoneal cavity; and (2) of infected blood alone, and with serous defects; using for this test pure cultures of common bacteria. He concluded that in the vast majority of cases neither blood alone nor with peritoneal defects produces adhesions. Furthermore, some of the cases with infection added showed none, although the majority of these did develop adhesions, especially those with raw peritoneal surfaces. Other investigators have reached the same conclusions. Flateau[7] leaves all blood in the peritoneal cavity in cases of ruptured extra-uterine pregnancy except that which escapes as a result of necessary operative manipulations. He condemns all efforts to remove it on the ground that it is impossible to get it all out, and that attempts to do so only serve to prolong the operation and to injure the peritoneum. Baisch,[8] on the basis of his experimental work, concurs with the view that the peritoneum is capable

[1] Studies on Peritoneal Adhesions, Ann. Surg., 1911, liv, 768–797.
[2] Deutsch. Arch. f. klin. Med., 1876, xviii, 542.
[3] Arch. f. klin. Chir., 1877, xx, 51.
[4] Deutsch. Ztschr. f. Chir., 1902, lxiii, 296.
[5] Arch. f. klin. Chir., 1888, xxxvii, 745.
[6] Ztschr. f. Geburtsh. u. Gynäk., 1907, lix, 313.
[7] München. med. Wchnschr., 1904, li, 42.
[8] Beitr. z. Geburtsh. u. Gynäk., 1905, ix, 437.

of absorbing large amounts of blood without resulting adhesions, if intact, but finds that whenever a serosa-free surface is present it always leads to adhesions.

The facts seem to be that blood alone in the peritoneal cavity seldom causes adhesions, but in the presence of infection or peritoneal trauma blood helps materially to cause the production of adhesions.

Sutures and Ligatures.—The relation of sutures and ligatures in the peritoneal cavity to adhesion formation has been carefully studied by a number of investigators. Hallwacks,[1] as early as 1879, showed that non-absorbable sterile ligatures in the peritoneal cavity were first surrounded by a circumscribed inflammatory zone and finally covered by a thin layer of granulation tissue which served to encapsulate the suture material which might finally become disintegrated through the action of the tissue juices and leukocytes. Rosenberger,[2] Tillmans,[3] TenBrink,[4] Kelterborn[5] and others later confirmed these observations.

On the other hand many observers have noted firm adhesions in the region of heavy silk ligatures, and in the presence of low-grade infection non-absorbable suture material often causes adhesions to persist.

Mechanical Injury.—All investigators agree that mechanical injury sufficient to destroy the endothelium of the peritoneum results in primary adhesions over the injured areas, but experimental as well as clinical results differ widely as to the character of injury necessary to cause permanent adhesions. Pankow,[6] in testing the relationship of denuded peritoneal surfaces to adhesion formation, was able to produce adhesions in only one-half of his cases by stripping the parietal peritoneum sufficiently deep to cause multiple punctiform hemorrhages. Franz found no adhesions following aseptic peritoneal defects. Sänger[7] concluded from operations in which portions of the parietal peritoneum were resected, that one wound surface is sufficient to produce adhesions, which inevitably follow, and that it is not necessary for two such areas to lie together for their formation.

Air Drying.—Very elaborate and interesting experiments have been carried out to ascertain the effect of air on the peritoneal endothelium and its relation to adhesion formation. The results of these experiments as well as clinical observations show that drying may so injure the peritoneum as to cause temporary adhesions, but it is doubtful whether these adhesions are ever permanent except in patients having a special tendency toward the formation of permanent adhesions.

Infection.—Adhesions are the most important means of defense against infection in the peritoneal cavity and at some period during each case of intraperitoneal infection which recovers they are practically coextensive with the infection. With the elimination of the infection these adhesions usually rapidly disappear by resolution and

[1] Arch. f. klin. Chir., 1879, xxiv, 122.
[2] Ibid., 1880, xxv, 771.
[3] Virchows Arch., 1879, lxxviii, 437.
[4] Ztschr. f. Geburtsh. u. Gynäk., 1898, xxxviii, 276.
[5] Centralbl. f. Gynäk., 1890, xiv, 913.
[6] Ztschr. f. Geburtsh. u. Gynäk., 1907, lix, 313.
[7] Ibid., 1884, xxiv, 1.

reabsorption except in the immediate vicinity of persisting foci of infection. Thus during the acute stage of a diffuse peritonitis of appendicular origin, the fibrinous adhesions are encountered everywhere, while ten days later with the subsidence of the diffuse lesion it is the rule to find only a narrow zone of organizing adhesions walling off a peri-appendicular abscess. With the drainage of the abscess even these adhesions usually disappear except in those cases in which the appendix still retains some active infection. In these cases the zone of adhesions is soon limited to the immediate neighborhood of the appendix and even these will usually soon disappear if the appendix is removed. There is still some controversy as to whether peristalsis is necessary for the freeing of adherent surfaces, but it seems probable that peritoneal rest during the acute stage and active peristalsis after the acute stage has passed in the means best calculated to get rid of adhesions. In patients not exhibiting a special tendency to adhesion formation continuing irritation is undoubtedly the chief cause of persistent adhesions. Extensive adhesions persisting in relation to a tube, ovary, gall-bladder, uterus or cervical stump usually signify that trouble still exists in these organs sufficient to prevent the reabsorption of the adhesions.

Cauterization by Heat.—Nothing illustrates the variability of factors governing adhesion formation better than the results following the use of the thermocautery in the peritoneal cavity. Thus Spiegelberg and Waldeyer,[1] v. Dembowski,[2] Franz[3] and Maslowski[4] found that it produces adhesions. Baisch[5] and Kelterborn,[6] on the other hand, were unable to confirm this work. TenBrink[7] produced adhesions with the cautery only when infection was present. Küstner[8] reports in detail a case in which a large ovarian cyst, with many pelvic adhesions, was removed, the actual cautery being used to sever the adhesions and also the pedicle of the cyst. At a second operation fourteen months later for postoperative hernia no adhesions were found where the cautery had been used. A possible explanation of these conflicting reports has been given by Vogel. He found that a superficial burning of the peritoneum generally gives rise to adhesions, but that none occur after a thorough cauterization with the formation of a thick eschar.

Prevention of Adhesions.—The best way to prevent adhesions is to avoid as far as possible all those causes which are known to favor their production. As far as possible all defects in the serosa should be covered by peritoneal flaps or grafts. However, in doing this great care must be used to maintain normal relationships, to avoid undue tension and to select proper suture material else the attempt to prevent adhesions may actually determine their formation under unfavorable

[1] Virchows Arch., 1868, xliv, 69.
[2] Arch. f. klin. Chir., 1888, xxxvii, 745.
[3] Ztschr. f. Geburtsh u. Gynäk., 1902, xlvii, 64.
[4] Arch. f. klin. Chir., 1868, ix, 527.
[5] v. Vleits: Ztschr. f. Geburtsh. u. Gynäk., 1890, xx, 384.
[6] Centralbl. f. Gynäk., 1890, xiv, 913.
[7] Ibid., 1898, xxxviii, 276.
[8] Ibid., 1890, xiv, 425.

circumstances. Many other plans have been devised for preventing adhesions, chief among which may be mentioned the interposition of non-absorbable or slowly absorbable substances such as silver foil, Cargyle membrane, animal, vegetable and mineral oils and even gases and liquids. All of these special methods have had their advocates but none have stood the test of time and most of them have been definitely proven to be worse than useless.

In conclusion it is well to emphasize the fact that adhesions do not always cause noteworthy trouble, and that possibly the best way to avoid unpleasant after-results, such as are usually ascribed to them, is to make sure that the operation actually cures the original lesion for which the patient is operated. Troublesome adhesions are particularly prone to develop around persisting foci of low grade infection. It is equally important for the operator to so arrange the position of the organs at the close of the operation as to insure normal relationships one to another in case adhesions do form subsequently.

Postoperative Intestinal Obstruction.—Intestinal obstruction may be either an early or late complication following abdominal operations.

Cases occurring immediately or within a few days following laparotomy have usually been classified under the following heads:

1. Septic ileus such as accompanies a septic peritonitis.
2. Paralytic ileus.
3. Mechanical ileus usually due to adhesions and conditions resulting therefrom.

Today the term postoperative obstruction is largely limited to the third group of cases due to mechanical causes which may make themselves manifest at any time following a laparotomy.

Cases of postoperative obstruction coming on immediately or a few days after operation were formerly of frequent occurrence and constituted one of the chief causes of mortality in abdominal surgery. In our experience and probably that of most surgeons in this country this form of postoperative ileus has almost entirely disappeared. Beckman reports only 3 cases of postoperative obstruction occurring during convalescence in the course of 4764 abdominal operations. During the past eleven years the writer has had no deaths from this cause and only 1 case requiring secondary operation.

Simplification of operative procedures, the application of better judgment as to what not to do when working in the presence of recent adhesions and inflammatory exudates, and the general introduction of more rational lines of postoperative treatment are the three chief reasons for the lessened incidence of this complication. It seems probable that the introduction of more rational lines of postoperative treatment is the principal reason for the reduction. The withholding of cathartics until normal bowel movements are obtained by enema, followed by the withholding of food and drink by mouth and the use of proctoclysis in patients with suspicious symptoms were important steps in the elimination of this complication. Another advance of almost equal importance has been the introduction of the prompt use of the stomach tube whenever postoperative cases became nauseated or distended.

As practically all statistics purporting to show the frequency of early postoperative obstruction are based on the results obtained during the period when early catharsis was supposed to be an essential element of after-care, they are entirely misleading as regards the present time. Late cases of complete obstruction occurring months or years after operation are very rare considering the great number of patients now living upon whom laparotomies have been performed. Nevertheless, every surgeon doing an active practice meets with an occasional case of complete obstruction and numerous cases of lesser grades of obstruction developing months or even years after operation.

Adhesions are the primary cause of the great majority of all cases and adhesions involving the small bowel are far more liable (93 per cent.—Woolsey) to cause acute obstruction than are those involving the large bowel. In a considerable percentage of cases it is found that the adhesion causing the obstruction has fixed a loop of small intestine in a grossly abnormal location in the abdomen. This cause of postoperative obstruction can be largely avoided by using care not to disturb the normal relationships of the organs during the placing of or removal of tampons or drains.

As a rule, cases developing acute intestinal obstruction after convalescence from the original operation should be operated upon immediately, because, even if they do obtain relief from enemas, there is almost no likelihood of the cause of the obstruction disappearing, and even if the acute attack is relieved the condition will almost certainly reappear. In any case operation should not be delayed more than a few hours. The mortality, if operated during the first twenty-four hours, is only nominal, while after twenty-four hours it rises very rapidly. Naunyn, in a study of 288 cases of acute obstruction found the mortality in cases operated the first or second day to average 25 per cent., while if operation was delayed to the third day or later the mortality was from 60 to 65 per cent.

The indications for immediate operation are less definite in cases occurring within a week or ten days following the primary operation because secondary operations performed at this time have a high mortality, and if they can be avoided the chances are that the adhesions causing the obstruction will be ultimately absorbed.

Secondary operations for the relief of obstruction occurring during early convalescence have a mortality of from 25 to 50 per cent., while wound infections and ventral hernias are particularly frequent in those who recover. Such operations are plainly to be avoided if possible, and yet to procrastinate when radical interference is demanded is usually fatal. In our own experience the following rule has always served to differentiate between the cases which have demanded operation and those which could be cured by conservative treatment. If no plainly evident results are obtained from two or three enemas given at intervals of two to eight hours, depending on the urgency of the symptoms, the obstruction is probably complete, and the patient should be operated before alarming symptoms set in. On the other hand, if each enema does yield a little result in the way of gas or fecal matter it has invariably been our experience that the acute stage of the obstruction will clear up without operation and a recurrence of the trouble has very rarely been noted.

LITERATURE.

Funk: Ueber Ileus Nach Laparotomie, Deutsch. med. Wchnschr., 1905.
Sonnenburg: Ueber Postoperation-Ileus, Berl. klin. Wchnschr., 1907, Bd. i.
Winternitz: Ueber operative Behandlung des postoperativen Ileus, München. med. Wchnschr., 1900, Bd. ii.
Martin: Postoperative Ileus, Deutsch. med. Wchnschr., 1907, Bd. ii.
Busch: Ueber postoperative Ileus, Berlin, 1912.
Funk: Acute Postoperativen Intestinal Obstructions, Jour. Indiana State Med. Assn., 1913, vi, 433–449.
McGlannan, A.: Intestinal Obstruction: A Study of 181 Cases, Tr. South. Surg. and Gynec. Assn., 1912, xxv, 26–51.
Woolsey, G.: Postoperative Intestinal Obstruction, Tr. Am. Surg. Assn., 1910, xxviii, 270–298.

Acute Dilatation of the Stomach.—Since the attention of the profession was forcibly called to this condition by Thompson,[1] in 1902, this rare but serious postoperative complication has been frequently recognized by all surgeons. It is also met with after labor and in many non-surgical diseases of the asthenic type. Within recent years the more severe cases have largely disappeared from clinics where the stomach tube is used to treat postoperative vomiting. Equally brilliant results are often obtained by having the patient lie on his stomach until the symptoms pass away.

Postoperative Ventral Hernia.—Abel[2] examined 586 patients sometime after laparotomy and found that ventral hernias had developed in from 9 to 20 per cent. of the scars depending upon whether the incision had been closed by approximation of the anatomical layers or by through and through sutures. Harrington[3] studied the postoperative condition of 236 patients operated for appendicitis; 85 were completely closed at the time of operation and of these 3.5 per cent. showed subsequent hernia; 88 were sutured down to the drainage tube or almost completely closed and of these 12.5 per cent. developed hernia; 63 were treated by the "open method" and 20 per cent. developed hernia. Since the time when the above figures were compiled the results have been greatly improved, but ventral hernias still constitute one of the chief causes of unsatisfactory end-results after laparotomies. Recent literature contains many references to descriptions of technical procedures designed to prevent or cure this condition but no comprehensive studies dealing with the frequency of this complication under modern conditions.

The following statements concerning the incidence of ventral hernias

[1] Acute Dilatation of the Stomach, London, 1902.
[2] Archiv. f. Gynekologie, 1898, lvi, 956–750.
[3] Quoted by Murphy in Keen's Surgery, iv, 793.

are based very largely on a personal study of the known end-results following approximately 2000 laparotomies:

After abdominal incisions of approved type, closed in such a manner that the anatomical structures are held in normal relationship one to another while healing by first intention, there is no noteworthy weakening of the abdominal wall. Any cause which interferes with the union of properly approximated surfaces predisposes to ventral hernia. Chief among these causes may be mentioned infection, early excessive strains on the incision, drainage, nerve injuries and obesity. In the average clean case the union at the end of two weeks should be sufficiently strong to withstand the strains of ordinary life, but from four to six weeks should elapse before hard manual labor is undertaken. In obese individuals and those suffering from constitutional defects such as marked anemia, jaundice, etc., due allowance should be made for delayed repair even though it be by first intention. If the incision has been infected the danger of subsequent hernia may be considerably reduced by insisting that no strain be placed on the wound for at least ten weeks after it has closed.

Ventral hernias following primary union of undrained abdominal incisions are very rare and when they do develop they are almost always the result of abnormal strains being placed on the sutures soon after the operation. Excessive postoperative coughing, especially in upper abdominal incisions, has been followed by ventral hernia in a number of patients who must certainly have escaped had it not been for the coughing. Obese patients may develop ventral hernia without the presence of any other demonstrable cause. In these cases the tissues which are relied upon to give strength to the incision are often themselves weakened by fatty infiltration, repair is slower than in normal individuals, the line of the incision must usually bear its share of the excessive weight, increased postoperative intra-abdominal tension is particularly common, and finally there is the well-known susceptibility to infection.

In the great majority of cases infection is the chief cause of subsequent yielding of the abdominal scar. With or without drainage frank infection involving the suture lines of the fascial layers results in ventral hernia in a very large proportion of cases. In mildly infected wounds not accompanied by frank suppuration along the fascial layers hernias are frequently determined by excessive coughing or other strains subjected to the wound before firm union has been completed.

Drainage *per se* predisposes to hernia in direct proportion to the size of the drains employed. While drained cases are very much more likely to be followed by ventral hernia than are clean undrained cases, the infection which necessitates drainage rather than the drains themselves is responsible for the resulting hernias in most instances.

In the writer's experience, rectus and midline incisions, in which drainage not over 3 cm. in diameter was employed and in which primary union of the remainder of the incision was obtained, have yielded not over 3 per cent. of hernias and these have been of almost no practical importance. On the other hand, if in drainage cases the closed portion of the incision has suppurated, hernias have developed in a considerable proportion of the scars depending upon the extent and duration of the suppurative process. Incisions which were packed open with little or no effort to obtain prompt closure have nearly all resulted in ventral hernias.

Harrington reported 3.5 per cent. of hernias developing in incisions for appendicitis which were completely closed at the time of operation. At first sight this figure seems high but it corresponds with our own observations in cases operated for acute intra-abdominal conditions. In my experience ventral hernias have been particularly frequent after operations for acute appendicitis in which the conditions within the abdomen did not demand drainage but in which the tissues of the abdominal wall were unavoidably infected during the operation causing a subsequent suppuration in the undrained incision. Similarly, infection in the main incision has been much more frequent when drainage was carried through a lateral stab wound than when it was brought out through the primary incision. Because of this fact, in the cases examined, lateral stab drains have been a cause of rather than a means of preventing ventral hernia. Data obtained from other sources would seem to confirm this view which is contrary to that held by many surgeons.

Although the theoretical advantage of the muscle splitting incisions of the McBurney type are well known, it is a fact worth noting that while the writer has never used this incision in operating for acute appendicitis and although it has not been commonly employed by other surgeons whose results we have had the opportunity to observe, nevertheless, a very considerable proportion of the most troublesome ventral hernias which have come under observation have followed so-called McBurney incisions. This point is of sufficient practical importance to warrant careful study of much more data before expressing a definite opinion. In so far as our own observations go the muscle-splitting incisions of the McBurney type are definitely more prone to give ventral hernias than are the incisions which depend upon the accurate suturing of fascia layers for their postoperative strength.

The end-results of secondary operations for ventral hernias depend largely upon the size of the hernia. Small hernias are easily cured while wide hernias have so far been followed by a large percentage of recurrences. Coley[1] reports 10 known recurrences following 61 operations for ventral hernia (16.4 per cent.) which is about the average reported by other surgeons. The introduction of the imbrication method of closing small and medium-sized hernias has apparently given better results than the old edge-to-edge approximation of the anatomic layers, and the use of the silver wire filigree has yielded good results in many cases previously inoperable.

[1] Progressive Medicine, June, 1913.

Cystitis.—Cystitis is one of the most frequent and distressing of the minor postoperative complications. It is particularly frequent after gynecological operations, and after pan-hysterectomy for cancer cystitis is so frequent and serious a complication as to have a decided bearing on the prognosis of the operation. Hemorrhoid and hernia operations as well as simple appendectomies are also often followed by cystitis. Its occurrence after such operations may mean that the patient has been relieved of one condition only to be left with a much more troublesome and possibly even dangerous infection of the bladder.

The causes responsible for postoperative cystitis are none too well understood. Formerly surgeons were agreed that infection introduced through catheterization was the immediate cause of the infection. More recently it has been recognized that this simple explanation is insufficient and that it is the abnormal condition of the bladder necessitating the catheterization which is probably the most important factor in causing the cystitis. The normal bladder is not easily infected even by catheterization. On the other hand, after certain operations, especially those involving the immediate neighborhood of the bladder, this organ becomes highly susceptible to infection which may develop with or without catheterization.

In attempting to reduce the frequency of this complication in our own cases it soon became apparent that extreme care used in catheterizing cases of postoperative retention had little effect on the frequency of cystitis. Likewise there was little or no demonstrable benefit from the prophylactic use of urinary antiseptics administered by mouth.

On the other hand, in the writer's experience cystitis as a postoperative complication has been practically eliminated since adopting the plan, in all cases of postoperative retention, of frequent catheterization followed each time by the injection into the bladder of one ounce of saturated boric acid solution which is allowed to remain until the next catheterization. This method of prophylaxis is simple and harmless and has apparently proved to be of real value.

Injury to the Ureter.—In 4086 major operations in the gynecological service of the Johns Hopkins Hospital studied by Sampson,[1] there were 32 known instances of injury to the ureter occurring during operation. A ureter was clamped sixteen times; a portion of the ureter was intentionally excised six times; a ureter was incised three times, a ureter was completely divided three times and the blood supply was so interfered with as to cause a subsequent ureteral fistula seven times. The ureter was tied or clamped three times in 50 abdominal hysterectomies for carinoma of the cervix; once in 26 combined abdominal and vaginal hysterectomies for carcinoma; three times in 63 vaginal hysterectomies for carcinoma of the cervix; four times in 516 hysteromyomectomies; twice in 276 hysterosalpingoöphorectomies for pelvic inflammatory disease; once in 63 repairs of vesicovaginal fistula; once

[1] Ligation and Clamping of the Ureter as Complications of Surgical Operations, Am. Med., 1902, iv, 693–700.

in 100 fixations of the kidney and once in a combined vaginal and abdominal colpohysterectomy for carcinoma of the vagina.

In a series of 310 intra-abdominal pelvic operations performed by the writer the ureter was injured twice. Once in ligating a deep pelvic vessel a ureter was punctured by the suture in such a way as to allow the urine to escape into the general peritoneal cavity with a fatal result. In the second case a portion of a ureter which was adherent to an intraligamentary cyst was excised along with the cyst. In this patient immediate nephrectomy was followed by recovery. In two other cases ureteral fistulæ developed following the removal of gauze packs which had been placed against the exposed ureter.

Although injury to the ureter is one of the rare surgical accidents, it is nevertheless of sufficient frequency to make it one of the most important single complications liable to be encountered in gynecological work.

Postoperative fistulæ developing in the presence of infection are followed by ascending infection and pyelonephrosis in a very large proportion of cases.

Divided ureters implanted into the intestine always result in ascending infection and the same may be said of the great majority of cases where the ureter is implanted into the bladder.

Uretero-ureteral anastomosis is sometimes successful but is more often followed by hydronephrosis and infection.

Permanent ligation of the ureter results in an atrophy of the kidney without recognizable clinical symptoms in the majority of cases, although in some cases ligation is followed by hydronephrosis.

Parotitis.—At the present time parotitis is a rare postoperative complication.

Stephen Pagent, in investigating the causes in 101 cases, found that in 50 cases parotitis arose after disease or temporary derangement of the generative organs; 23 cases of parotitis arose after disease or injury of the abdominal wall, peritoneum or pelvic cellular tissue; 18 cases arose after disease or injury to alimentary canal; 10 cases arose after disease or injury of the urinary tract.

In our experience it has usually followed operations for some form of acute intraperitoneal infection. It is an exceedingly distressing complication which may occasionally determine a fatal termination in patients already handicapped by serious illness.

Postoperative Intestinal Fistulas.—Postoperative intestinal fistulæ occur most frequently after operations for acute appendicitis. They are also met with after operations for pelvic infections and after other intra-abdominal operations undertaken for the relief of long-standing infection. Sometimes they follow leakage from the suture lines after intestinal anastomoses.

Chronic tubercular infections within the abdomen are very frequently accompanied by small fistulæ into the intestines which may not be discovered until a fecal fistula has developed.

The great majority of fecal fistulæ close spontaneously. Serious complications are seldom encountered unless the fistula be in the duodenum or jejunum when the loss of semidigested food through the fistula may interfere with the nutrition of the patient. In appendix cases and after pelvic operations the fistulæ usually close spontaneously in from ten to fourteen days. Fistulæ in cases of tuberculosis are always serious but some of them close spontaneously. Those following anastomosis operations usually spell failure although occasionally one may close without further operative interference if there be no obstruction at or distal to the anastomosis. When an ordinary fecal fistula fails to close spontaneously the failure is usually due to some obstruction in the intestine distal to the fistula.

In the past leakage from the intestine has often been caused by gauze packs placed against suture lines, appendix stumps or weakened intestinal walls. Others have been due to pressure necrosis from glass or stiff rubber tubes.

During the past few years the incidence of fecal fistula has been so markedly lessened as to make worthless all of the older data concerning the frequency of this complication.

Nerve Injuries.—Injuries to important nerves often mar the results of otherwise successful operations. Only extreme care and a thorough knowledge of anatomy will suffice to avoid these injuries. Facial paralysis following mastoid operations and operations in the upper cervical and parotid regions is relatively frequent and of great importance. Injury to the spinal accessory is a common complication of operations in the cervical region. Abdominal incisions should be so planned as to avoid injuring the nerve supply to the abdominal muscles as otherwise serious weakness of the abdominal wall may result. Injuries and operations on the extremities are always liable to be accompanied by serious nerve injuries. Suture of the divided nerves yields good results in many cases but the process of repair is very slow and the percentage of failures is high.

Musculospiral paralysis due to the arm resting over the edge of the operating table while the patient is under the anesthetic is one of the most distressing of the avoidable postoperative complications. With constant attention to details this complication can be avoided, but with the least carelessness it may occur with considerable frequency. The patient, operated for some minor disability and left with a painful crippled arm for six months or a year after the operation, is a sad victim of misplaced confidence.

Scars.—The possibility of unsightly scars must always be borne in mind, especially when operating on the face and neck. Scars may have little bearing on the postoperative result viewed from a purely scientific standpoint, but the talkative woman who has been relieved of a disfiguring goiter and left with a slight scar visible only, on party occasions, is prone to forget the goiter and dwell on the disfigurement caused by the scar.

Artificial Menopause.—In women who have had both ovaries removed before the period of the natural menopause, there results an artificial menopause characterized by phenomena similar to those seen at the natural menopause, only often in a peculiarly exaggerated form.

Gynecologists still differ in their opinions concerning the effect of the removal of the uterus with the preservation of one ovary on this condition, but most surgeons have long been convinced that the preservation of an adequate amount of ovarian tissue is the essential factor in avoiding these phenomena. Dickinson,[1] after studying 164 cases, arrives at the following conclusions:

"Conservation of the ovarian structures after hysterectomy show four-fifths of the patients free from marked disturbance of the surgical menopause. The results are somewhat better where both ovaries remain than where one is left or resections are made.

"Where disturbances do occur their character is less severe and more gradual than after bilateral removal of the ovaries. In married women conservation shows nearly uniform persistence of sexual desire."

To preserve the functional activity of the ovary its circulation must not be impaired. Removal of the tube frequently compromises the blood supply and barring definite evidences of disease the tube should be preserved when the ovary is preserved in doing a hysterectomy.

The disorders of the artificial menopause are flashes or flushes of heat, palpitations, hysteroneuroses and physical disturbances. The flushes come on, as a rule, within a few weeks after operation and persist for periods of time varying from a few months to several years. Their intensity grows less, usually, in a few months. They frequently appear even forty to fifty minutes while the patient is awake, and are sometimes preceded by a slight faintness, chilly sensations or dizziness. The patient feels that she is pale and that the blood is leaving the surface of the body. This is followed by a wave of heat which rushes over the surface of the body, particularly the face and neck, causing burning, tingling and flushing of these parts, and this is succeeded by sweating. The patient may complain of her heart beating very forcibly, the thumping of which she can hear. The flushes are nervous phenomena, the vascular system responding to the same sort of stimulus which causes blushing.

Palpation and tachycardia, which may or may not accompany the flushes or may appear independently, are likewise due to a disturbed nervous system.

The hysteronervous and psychic phenomena are those of other forms of neurasthenia, but are frequently seen in women who have previously been free from them.

Many surgeons believe that the morbidity due to the artificial menopause is not to be compared to the bad results following attempts at conserving one or both ovaries. The viewpoint of surgeons opposed to conserving the ovaries has been recently emphasized by Polak,[2] who found that 43 women in whom both ovaries were removed

[1] Tr. Am. Gynec. Soc., 1911, xxxvi, 324. [2] Ibid. i, 329.

were completely relieved of all pelvic pain and symptoms, only 3 suffered from flushes, and only 1 suffered from marked nervous phenomena. Of 32 women in whom one or both or a part of one ovary was saved 5 had enlarged tender ovaries which caused them pain; 3 of the 32 women suffered from nervous phenomena which could hardly have been worse.

Postoperative Susceptibility to Fatigue and Postoperative Neuroses. —Following the average clean laparotomy the histological processes of repair are essentially completed by the end of the second week, and by the end of the third week there is seldom any objectively demonstrable reason why the patient should not return to his usual routine of daily work. As a matter of fact, the patient is almost never able to do this. The patient operated upon for some relatively minor ailment is weak out of all proportion to any objectively demonstrable cause. There may not have been a degree of temperature nor any noteworthy acceleration of the pulse, there may have been no loss of weight and he may look the picture of health, yet the inability to carry on sustained effort may be even more pronounced and may persist for a much greater length of time than after a really serious medical illness of approximately equal duration. The patient interprets his condition, not in terms of pain or other phenomena directly referable to the operation itself, but in terms of *weakness*. He feels compelled to wait weeks or even months to "recover his strength."

In the light of our present knowledge this postoperative susceptibility to fatigue can best be explained as the result of a profound impression on the central nervous system or the central nervous system plus associated organs controlling psychic and possibly muscular activities.

In this connection it should always be borne in mind that a surgical operation is, for possibly the majority of patients, a great crisis in their lives. Fear, worry, anxiety and physical suffering are superimposed one upon another and crowded into an interval of a few days or hours in such a way as to tax the strongest nervous system. It is, therefore, little wonder that the strain leaves an impression on the nervous and psychic centers of a considerable proportion of patients. The phenomena referable to this strain usually disappear slowly but certain effects may persist in the form of more or less permanent neuroses.

Crile and his followers believe that the phenomena under consideration are the result of exhaustion beyond the limits capable of prompt repair of those organs whose function is that of converting latent energy into kinetic energy in response to adaptive stimuli. They also claim that the changes incident to the exhaustion are demonstrable histologically by structural alterations in the cells of these organs, the degree of pathological alteration being directly proportionate to the degree of overstimulation due to noci impulses. According to them the cells of the central nervous system are chiefly affected but the suprarenals, liver, thyroid and muscles may also be involved in the changes incident to the exhaustion of overstimulation. Whatever the final verdict concerning the histological aspects of the subject may be, there is no questioning the fact that increased susceptibility to fatigue is readily demonstrable after the majority of surgical operations and after many non-operative traumas, especially those accompanied by considerable fright.

In the great majority of cases this condition amounts only to a more or less prolonged period of weakness; the patients subsequently stating that following the operation it took six weeks, six months or even a year to recover their strength. Nevertheless, in considering the prognosis of an operation the surgeon must always bear in mind the possibility of producing a true postoperative neurasthenia or even hysteria and very rarely insanity.

The postoperative neuroses are not different in kind from the well-known traumatic neuroses. It is noteworthy, however, that whereas the traumatic neuroses have been fully recognized for many years, surgeons have, for the most part, failed to recognize the fact that many of the neuroses following operation were the direct result of the pain, fear, anxiety and other noxious influences incident to the operation itself, and that the operation was often the principal and not infrequently the sole cause of the trouble, even though there were no demonstrable anatomic defects resulting from the surgical manipulations themselves.

Not only is it important to avoid the so-called noci-association before and during operations, but it is equally important that following an operation or injury the patient's mental attitude be guided into proper channels. The man or woman who has received an ordinarily unimportant injury but who looks forward to a substantial compensation for "permanent injury to the nervous system" is almost invariably placed in a mental attitude which continues the traumatic neurosis until after the litigation is ended. Likewise the patient who has undergone an operation and later develops the mental attitude of self-pity for each little ache and pain is almost sure to continue in a state of more or less pronounced "shell-shock." If, on the other hand, the patient can be brought to think constantly of how fortunate he or she is that the operation is passed, that no serious, life-threatening conditions such as cancer were found, and to interpret each little ache and pain as only a natural step in the convalescence, from a condition which might have been infinitely worse, then in our experience the recovery from the nervous manifestations is prompt and positive. We believe that this question of abnormal mental attitude is so important a factor in most cases of traumatic and postoperative neurosis that the effort to develop a correct mental attitude has for years formed the chief basis for our therapy in these cases.

It is a noteworthy fact that patients operated for real pathological conditions, be it a pelvic abscess, a cancer of the breast, an empyema of the gall-bladder or an acute appendix, seldom suffer from postoperative neurasthenia; while the patient whose abdomen is explored without positive findings is more than likely to suffer from nervous symptoms greatly exaggerated by the operation.

TECHNICAL EFFICIENCY.

By ALBERT J. OCHSNER, M.D.

The idea of attaining technical efficiency has invaded almost all fields of human activity. In the industries this has taken so important a place that corporations employ efficiency experts in order to be enabled to meet competition.

In surgery, little attention has been given to this field, although here and there individual surgeons have grasped the idea and have developed systems far in advance of others in this direction.

Several elements are involved in the development of efficiency.

1. **Concentration.**—Concentration of attention and energy are of primary importance. If the surgeon regularly concentrates his attention upon the work before him, his assistants and nurses will soon acquire the same characteristics, and an endless waste of time can be eliminated.

2. **Preparation.**—If the operation has been thoroughly planned and everything is in readiness not only for the operation but also for possible emergencies and for the surgical dressing, much efficiency will result.

3. **System.**—The surgeon who has observed a large number of capable surgeons operate, can avoid a vast amount of unnecessary manipulation because he can develop a system which will eliminate everything useless in all of the methods observed and at the same time he can adopt all of the points which make for efficiency.

4. **Constancy of Working Plan.**—By developing a working plan which is constantly in use in a hospital all of the persons involved, operator, assistants, anesthetist and nurses know what will be expected of them and will be ready to do their part promptly and efficiently, while a rattle-brained operator who does the same things in a number of different ways, according to the whim that strikes him, cannot count on efficient coöperation.

5. **Limited Number of Assistants.**—Clinics in which a large number of assistants and nurses are involved in each operation must lack efficiency because everything handled is likely to pass through a number of hands, and at each handling there is an opportunity for loss of time, infection and error.

6. **Instruments.**—It is much more likely to develop a high degree of efficiency if the surgeon and each assistant handles the instruments which he uses rather than to have them passed to him by a nurse or another assistant, because it requires but one mental act and one motion for each change of instruments, provided they are always placed in the

same relative position when these are not handed to the surgeon by a second person. On the other hand, if they are handed by a nurse or an assistant, whenever the surgeon decides upon the next step, if the assistant happens to have thought of exactly the same step he may anticipate the operator; if, however, the surgeon must call for the instrument, or if the wrong one is handed to him, there is a loss of time and energy, and usually some mental irritation, all of which conditions do not make for efficiency.

Automatic Action.—Everything that we do really very well we do more or less automatically, and, other things being equal, the more we can introduce this element into surgical technic the greater will be our efficiency.

Arrangement of Operating Room.—Much can be accomplished to increase efficiency by carefully studying the arrangement in the operating room. By studying the motions required in doing surgical work and observing the distances to be traveled in accomplishing the work, one can arrange the furniture and apparatus in the operating room so as to reduce to a minimum the waste of energy required and this will of course increase the efficiency.

ASEPTIC AND ANTISEPTIC TECHNIC.

By ALBERT J. OCHSNER, M.D.

The practice of antiseptic surgery was based upon the knowledge that suppuration and inflammation occur only in the presence of microorganisms in the tissues involved and upon the supposition that these microörganisms should be destroyed by the introduction of some substance or some combination of substances which has been demonstrated to possess the power of destroying microörganisms or to inhibit their growth or their power of reproduction to a sufficient extent to enable the tissues to destroy them. Aseptic surgery, on the other hand, attempts to accomplish the same result by keeping wounds free from microörganisms to a sufficient extent to enable the tissues to destroy the very small number which may obtain entrance into the wound, notwithstanding any precautions that may be taken.

When we come to consider the practical details of accomplishing these objects, however, so many conditions have a definite and important bearing upon the results in wound-healing that it is quite worth while to go into details.

These will be considered in an intensely practical way in order to give them the position they deserve in the planning of actual surgical work.

At the present time aseptic methods are almost universally employed in the treatment of wounds that are made by the surgeon in tissues which are not already infected. This is proper because none of the antiseptics can in any way benefit the tissues of wounds which are free from infectious material, while undoubtedly many of the antiseptic substances which have been introduced into practice have harmful effects upon the tissues.

It is at the same time possible to prevent the introduction of microorganisms into these wounds to so great an extent that the slight number which may be introduced accidentally can be easily disposed of by the natural action of the tissues, provided these tissues be given a fair chance to defend themselves against these intruders.

We must then provide against the introduction by contact of microorganisms into the uninfected wounds. The fear of infection from microörganisms in the air has been proved to be unfounded. Exposing culture plates in an operating room will demonstrate that the air practically always contains microörganisms, the number varying with the amount of dust present; but even in operating rooms, in which a large number of microörganisms are present in the air, infection of wounds will not occur provided precautions are taken against contact infection.

I recall some notable examples in my personal observation which may serve as illustrations. While serving in the capacity of surgical assistant in one of the clinics connected with a medical college thirty years ago, when this subject was in its developmental stage, I had an opportunity to observe the work of two of the members of the hospital staff who were at the same time members of the surgical faculty of the college.

One of these surgeons performed his operations in the hospital operating room, which was cleaned and disinfected with the most scrupulous care. Everyone in the operating room wore a sterilized gown and every possible precaution was taken to prevent air and contact injection. Before important operations the air was sprayed at times by means of an atomizer with 5 per cent. carbolic acid solution. The conditions, in other words, were quite as perfect for performing an aseptic or antiseptic operation as they are now in our modern hospitals.

The other surgeon performed his operations in a public amphitheater with five hundred seats, most of which were usually filled with students and practitioners. These surgical clinics were conducted three afternoons each week, while on the opposite days the same amphitheater was used by the professor of anatomy in the demonstrations upon the cadaver.

The dissecting room was located in the story above the amphitheater, and many of the students came directly from their dissections to the surgical clinic without stopping to change their clothing.

Occasionally the amphitheater was swept and dusted. The floor of the operating pit and the surrounding woodwork were washed with 5 per cent. carbolic acid before the operations, and everything that was likely to be touched by any one connected with the operation was covered with sterile sheets. During each month more than one hundred operations were performed in this operating room. The assistants and nurses, instruments, ligatures and sutures and supplies for both surgeons were supplied by the hospital and were identical. In the one case the wounds healed by primary intention almost without exception, not even a stitch abscess being present; in the other instance absolutely aseptic healing was practically unheard of, there being at the very best a few stitch abscesses.

The surprising feature being that all of these infections occurred in the practice of the surgeon whose work was done in an ideally prepared operating room while none occurred in the dirty college clinic room.

It is needless to state that when the surgeon who conducted the public clinic performed his private operations in the aseptic operating room in the hospital on the alternate days that the wounds made there also regularly healed by primary union.

These observations were most convincing of the fact that there is no infection in surgical practice except contact infection, to which should be added infection from saliva thrown into the wound by speaking while facing the operation wound.

The observation described above confirmed a similar observation I had made in two foreign clinics in which two gynecological surgeons were working in adjoining buildings. One of these operated in a large amphitheater open to all students and visitors; these were not required to take any antiseptic precautions. The second clinic could be visited by only a few visitors each day and all had to be covered with sterile caps and gowns. The former I visited daily, the latter rarely, because special permits were difficult to obtain; but I visited the necropsy every morning, and to my amazement I never saw a cadaver that had been operated in the former clinic who had died from peritonitis during a period of two semesters, while the latter clinic furnished a considerable number of these cases, so much so that one morning when the old professor of pathology saw the professor of gynecology enter the necropsy while he was personally making the rounds, greeted his colleague with the enthusiastic exclamation, "Ah, Colleague! here we again have one of your wonderfully typical cases of peritonitis." This observation was made more than a third of a century ago and the intervening years have convinced me that the former surgeon did nothing which could cause contact infection because his attention was centered upon essentials while the patients of the second suffered because his attention was so thoroughly filled with many non-essential details that in some way he overlooked some element which resulted in contact infection.

There can be no doubt but that practically in every case of infection the microörganisms determining the kind of infection were placed in the wound by some object which in turn had come in contact with infectious material, and that if such conditions are established that this cannot happen, that then the wounds will remain aseptic.

A most perfect system has been developed, for example, by Sir Arbuthnot Lane in connection with his operations upon bones. In these operations the following procedure is employed: (1) All instruments, sponges, ligatures, sutures and dressings are prepared so that they are absolutely sterile. The surgeon's hands are covered with sterile rubber gloves. The skin is rendered sterile so far as this is possible. After the primary incision through the skin, its edges are covered with sterile towels fastened in place by means of suitable clamps in order to prevent infection of the wound by transfering staphylococci which had not been removed from the skin at the time of its disinfection. The knife with which the skin incision was made is then laid aside, and from this time on no one except the operator touches either instruments or wound except with instruments or sterile sponges.

In this manner infection can be prevented with certainty. There is no reason why most of the other operations could not be done according to this perfect system although this is not necessary in most cases because primary healing of wounds occurs regularly if every one connected with the operation is surgically clean. It is, however, far better to err on the safe side than to expose the patient to even a slight infection by overlooking any detail. The following bacteria give rise to infection of wounds:

1. The pyogenic cocci.
   Staphylococcus pyogenes aureus.
   Staphylococcus pyogenes citreus.
   Staphylococcus epidermidis albus.
2. Streptococcus pyogenes.
   Streptococcus hemolyticus.
3. Bacillus coli communis.
4. Bacillus pyocyaneus, produces bluish green pus.
5. Pneumococci.
   Other bacteria occasionally found in suppurating wounds.
   Bacillus typhosus.
   Micrococcus tetragenus.
   Bacillus diphtheriæ; Klebs-Loeffler bacillus.
   Gonococci.
   Bacillus of tetanus.

Gas Gangrene:
B. aërogenes capsulatus; B. welchii.
Vibrion Septique.
Bacillus edematicus; bacillus of malignant edema.

Of these the Staphylococcus aureus and albus are the most common and at the same time the least harmful; the latter of these is almost universally found in healthy skin, frequently located too deeply to be reached and destroyed by the antiseptics commonly in use for disinfecting the field of operation. One is consequently likely to carry some of these bacteria into the wound from the exposed wound edges unless the wound itself is protected by fastening aseptic towels along the skin edge of the wound before manipulating the deeper tissues.

As a matter of fact, wound infection during the operation is almost always due to the fact that some one person connected with the handling of the wound or some of the articles coming in contact with it does not give his undivided attention to the work in hand. An excellent illustration to prove this theory can be found in the fact that whenever some new method is on trial at any hospital so that the interest and attention of the entire staff is centered upon the details of the operations, one is sure to find an absence of infection, while slight infections will again occur after the interest has worn off.

The tissues, are, however, capable of disposing of a considerable number of microörganisms, providing favorable conditions are established while under unfavorable conditions the same number of microörganisms will give rise to stitch abscesses or more serious complications.

The conditions which favor infection due to a number of microorganisms which would not ordinarily cause trouble are: (1) the presence of dead space; (2) blood clots; (3) traumatism of tissues; (4) drawing of sutures too tightly; (5) grasping large portions of tissues at bleeding points and tying ligatures around these too tightly; (6)

tissues poorly supplied with blood; (7) bandages applied too tightly interfering with circulation; (8) ragged edges of wounds; (9) carelessly placed drainage tubes or gauze tampons interfering with the circulation; (10) badly planned skin flaps.

Ordinarily portions of the body which are especially well supplied with blood show great resistance against infection. Among these we may enumerate the tissues of the face, especially the lips and cheeks and the tongue. The peritoneum is very resistant to infection; this is also true of the mucous membranes. Whenever there is accumulation in a cavity lined with mucous membrane such as the urinary bladder, the pelvis of the kidney or the gall-bladder, the mucous membrane becomes infected. This is also true of the serous membranes of the joints. Willems has shown that if open infected joints are moved actively or passively every two hours, the synovial membrane will recover because this will prevent an accumulation of septic fluid; on the other hand, if the same joint is held quiet so that the fluid can accumulate there will be a destructive inflammation.

Medullary tissue of the bone is very susceptible to infection. This is also true of loose connective and adipose tissue.

The condition of the patient affects the susceptibility to infection. The following classes of patients lack resistance:

1. Patients exhausted from fatigue or exposure to cold and wet.
2. Diabetics and nephritics.
3. Those weakened from disease.
4. Those weakened from intemperance.
5. Those weakened from extreme old age.

TECHNIC OF ASEPTIC OPERATION.

In my practice aseptic surgery was substituted for antiseptic surgery in the year 1888 as a result of the following observation:

On the same day my chief, Professor Charles T. Parkes, operated upon a number of patients, among them three in whom he performed abdominal sections and one in whom he made a complete removal of the breast. As chief of his clinic I had superintended all of the antiseptic preparations and directed every detail, so far as handling of instruments, sponges, sutures, ligatures and antiseptic solutions were concerned.

The abdominal wounds healed without a drop of pus while the breast wound showed a considerable amount of irritation, which, however, subsided shortly. This difference in the action of wounds made under the same careful supervision attracted my attention and resulted in a careful review of each step of the operations, and this resulted in the discovery that the only difference in the methods applied consisted in the fact that the breast wound had been carefully irrigated with a solution of corrosive sublimate, which could, of course, not be applied to the abdominal wounds.

A further examination of previously operated cases showed that in a very large number of abdominal sections we had experienced no infections, all wounds having healed in an absolutely aseptic manner, while in the other wounds we had observed some disturbance in a few cases.

Abandoning the use of antiseptic material in all clean wounds the healing immediately became uniformly perfect. We continued the use of antiseptics in presumably infected wounds, probably to the detriment of the patient, because as we have abandoned this practice, our results became more and more satisfactory.

Our present method of treating infected wounds is fully discussed in the section on Military Surgery, so it need not be repeated here; suffice it to say that before the war for a number of years our faith in the value of antiseptic substances had dwindled down to a kind of superstitious belief that there is some virtue in tincture of iodin which we apply in the preparation of the skin in the field of operation and in the treatment of compound fractures. Dakin's solution and dichloramine-T we have adopted during the war. The application of these antiseptic substances have been described elsewhere in this work.

Preparation of Hands.—The first important point to be borne in mind regarding the preparation of the hands of surgeon, assistant and nurse refers to general cleanliness.

The hands should be kept away from unclean materials. A surgeon who is careless about handling unclean things is much more likely to be a carrier of microörganisms than one who is habitually clean.

Again, it is important to keep one's hands covered with smooth non-irritated skin which will shed dirt more easily than a roughened skin. If any particular substance causes an irritation of the surgeon's skin that substance should be discarded permanently, because of all the substances in use there is not a single one that is indispensable. This can be easily proved by the fact that if a surgeon washes his hands carefully with soap and sterile water and does not use a single one of the many antiseptic substances that have been lauded, his wounds will heal without infection, provided he eliminates all other sources of contact infection.

We have proved this fact in a large number of consecutive cases.

Still almost every surgeon has some special antiseptic lotion which he has used for a long time and in which he has a kind of faith akin to superstition, and whose systematic use gives him a feeling that he has done his utmost, a kind of virtuous feeling. So long as the substance is quite harmless it seems entirely proper to continue its use indefinitely.

It is certainly important that the surgeon develop an antiseptic conscience, and it is quite important to develop a degree of enthusiasm upon this subject in everyone connected with making of wounds and caring for them, and it seems necessary to have some superstition or other to maintain the necessary attention, concentration and enthusiasm.

The important points in rendering the hands aseptic consists in careful washing, preferably first in a deep basin filled with warm water, with the use of a soft cloth and an abundance of green soap. We have found that the skin becomes clean much more rapidly when the hands are scrubbed in this manner under water than when this is done under the stream of a faucet.

After the hands have been thoroughly washed in this manner the nails are cleaned with a blunt-pointed instrument and then these are brushed thoroughly with a soft brush under water. The forearms should be washed to a point above the elbows in the same manner. The forearms and hands are then washed under a stream of sterile water, in order to wash away the soap. After this has been done it does not matter what further steps are taken so long as the substance used does not harm the skin. Alcohol is probably as desirable as any substance, because it dissolves any fatty substance which may not have been dissolved by the soap. A solution of 1 to 2000 of bichloride of mercury in water may be employed safely unless the skin is sensitive to this solution, which is the case only very rarely. A $\frac{1}{4}$ per cent. of formalin in water may be used, but this is exceedingly irritating to the skin in many cases.

It is important that the hands be washed thoroughly. Of course, an active person can clean his hands as thoroughly in one-tenth of the time that it will require a phlegmatic, slow moving person to accomplish the same end, but it may be well, in a surgical clinic, to have a regular time of at least five minutes to be devoted to preparing the hands before operations. During the time consumed in doing this the person's attention should be directed upon the result to be accomplished. Too often too little attention is given to this, and the matter of preparing the hands proceeds as a kind of ceremony instead of making it an important matter of business.

In case the surgeon's hands become rough or irritated it is practically always possible to determine the cause of this irritation. It is usually best, under this condition, to have the surgeon take a vacation from his work in order to permit the skin to become quite normal. Upon resuming his work he should use only soap and sterile water for a number of days. Then if the skin shows irritation he should discard the use of the kind of soap he is using and should use only pure castile soap, which is made of vegetable fats, such as olive oil, and which practically never causes irritation.

If the soap and water do not cause any irritation of the skin he should use only one other substance for a period of a month, preferably grain alcohol. If this causes irritation it should be discarded, if not any other substance desired may be added for the next month. In this manner the irritating substance can be readily discovered and none of these substances are necessary and may be discarded without causing any harm.

It is well to bear in mind that the denatured alcohol in the market at the present time may contain some irritating substance which has been introduced for the purpose of changing pure alcohol into the denatured product.

The most common of these substances are formaldehyde and some of the coal-tar products. Camphor is the least irritating substance, which is in common use for the purpose of producing denatured alcohol.

Rubber Gloves.—It is important to disinfect the hands with exactly the same care whether or not rubber gloves are used because a tear may occur in the glove or the necessity may arise for the removal of the glove during the operation, in order to increase the acute sense of touch, and in either case, if the hands were not absolutely clean, an infection might result.

Ordinarily an operation can be performed nearly as rapidly and as well if the surgeon's hands are covered with gloves, and as these can be thoroughly disinfected by boiling, they are, of course, readily rendered absolutely sterile.

There is an advantage in the use of rubber gloves which is not fully appreciated. The surgeon is much more likely to tie his ligatures and sutures tightly enough to cause pressure necrosis, working with bare fingers because the gloves cause the ligature to slip while tying, giving the patient the additional protection against too tight sutures and ligatures.

It is of special importance always to wear gloves in operating upon patients with infected wounds and in dressing infected wounds.

In the latter case it is well, even if gloves are being worn, to handle all infected substances with forceps, because it establishes the habit of keeping one's hands out of unclean substances, and it is specially important to have the assistants and nurses to become habitually clean.

Everyone should habitually remain clean before, during and after operations and dressings and at all other times, and when accidentally the hands are soiled, they should be rendered surgically clean at once during operations or dressings, and as nearly as possible so at all other times.

It has been proved, by means of a long and carefully carried out series of experiments by Sprengel, that sterile gloves on the surgeon's hands which have come in contact with pus can be rendered sterile again by simple washing with hot water while still on the hands of the surgeon. The knowledge of this fact may serve to save time, for the patient occasionally, when a few minutes wasted, may be of importance, but, as a rule, it is such a simple matter to change the soiled gloves for clean ones that this plan should be preferred.

Disinfection of Skin Preliminary to Operation.—Before every operation if his condition permits it is well to give the patient a warm tub bath, using a good quality of soap and a large soft wash cloth made out of Turkish towelling, because in this way the loose epidermis and the excretions from the sebaceous glands of the skin can be removed.

Two precautions should be taken, however: (1) the bath tub should be thoroughly scrubbed with soap or some cleaning powder and hot water and then with some disinfectant, preferably with $\frac{1}{4}$ per cent.

solution of formalin in water, because if this or some similar plan is not carried out bath tubs are likely to become a source of infection. As a further precaution the nurse who prepares the bath should be instructed invariably to run boiling water into the tub until a sufficient amount has accumulated approximately to give the bath a proper temperature after cold water has been added. The hot water should remain in contact with the tub for several minutes before the cold water is added.

A second precaution should be borne in mind, namely, that it is not safe for patients who are accustomed to wearing woollen undergarments and woollen night garments to be placed in what in some stupidly conducted institutions are known as regulation sterile garments for surgical cases. The patient should be placed in clean underclothing of the type to which he has been accustomed; these need simply be freshly laundried, but need not be surgical aseptic.

Many so-called ether pneumonias undoubtedly result from neglecting this precaution or from failing to protect the patient properly when transported to or from operating rooms and during the time taken to perform the operation.

The day before the operation it is well to wash the field of operation and a large area surrounding the field with soap and warm water, preferably using a large piece of sterile gauze as a wash cloth. It is usually well to shave this entire surface at the same time and then to wash it with alcohol and to apply a sterile dressing in a manner to prevent the patient from touching the surface.

This can also be postponed until the patient is taken to the operating room. In this case, however, it is better to wash the entire surface with benzine first, then to dry it perfectly, permitting all of the benzine to evaporate, then to wash with alcohol and then to apply a mixture of tincture of iodin, U. S. P., and grain alcohol in equal parts to the surface, which should be permitted to dry before the operation is begun.

Another simpler method which has given equally satisfactory results consists in simply washing the field of operation with soap and warm water immediately before the patient is taken to the operating room and then washing the field of operation and the surrounding areas with benzine very carefully, and drying the surface in order to prevent irritation from the benzine, and then to paint the entire surface with the tincture of iodin and alcohol mixture described above. There is some danger of blistering of the skin especially if the second method described has been used, but if one is careful to dry the surface and to prevent the benzine from running into any creases of the skin, or to moisten the sheet underneath the patient, there is little danger from this source.

We have, however, abandoned the use of benzine and soap and water at the same time, and have simply, of late, in cases which for any reason could not receive any preliminary preparation on the day preceding the operation, washed the surface with benzine, then shaved the surface dry, then again washed it with benzine and then we have applied the tincture of iodin and alcohol mixture immediately before beginning the operation.

Disinfection of Instruments.—All instruments after being used should be carefully washed with a brush in lukewarm water and soap. It is best not to use cold water, because this is likely to roughen the nurses' hands, neither should hot water be used, because this will coagulate the blood on the instruments and will make the washing more difficult.

Instruments should never be permitted to stand in water, because this causes rusting.

After washing the instruments they should be boiled for one-half hour in water to which half an ounce of bicarbonate of soda in the form of ordinary baking soda has been added to the gallon of water. This will prevent rusting. They should be dried out of the hot water and placed in a case protected from dust. Before using these instruments again they should be boiled again in the same alkaline solution for two to five minutes.

Knives and scissors should be washed with special care then carefully wiped with 95 per cent. alcohol and then boiled for two minutes. Long-continued boiling oxidizes the sharp edge of the instruments. The precaution should be taken never to lay down soiled knives or scissors without having wiped them clean with a moist, gauze sponge. This can be done without loss of time during operation. Instruments will be improved if rubbed with liquid paraffin when put away.

Preparation of an Operating Room.—Ideal temperature is 80° F. Close all windows and keep closed during operation. Disinfect floors, tables, stands, etc., with phenol, solution of 5 per cent., or formaldehyde solution ½ per cent. Dust carefully electric lights and doors with moist cloth. Cover radiators with sheets. Place sterile scrub basins, soap, brushes and nail cleaner in scrub stands. Bring in all necessary supplies, such as linen, solutions, etc., to be used during day's operation.

After-care of Operating Room.—Ventilate well by opening all windows Remove all supplies. Wash all stands, tables, windowsills, etc., with soap and water, to which ammonia has been added. The floor is mopped with an antiseptic solution after scrubbing with soap and water.

Instruments.—Wash in lukewarm water, as hot water coagulates blood. All instruments, with the exception of those having cutting edges, should sterilize at least twenty minutes. Needles and scissors are sterilized five minutes only, to prevent cutting edge from becoming dull. To prevent instruments from rusting and also to soften water add sodium bicarbonate, 1 per cent. Instruments from septic operations must be taken care of separately. Use distilled water for sterilizing instruments whenever possible.

Disinfection of Catheters.—Rubber catheters to be boiled for ten minutes only. Filiform bougies, silk catheters and hard-rubber catheters are washed thoroughly with green soap and then with a saturated boric acid solution, then suspended in tall glass jars in the fumes of formaldehyde, produced by pouring formaline upon cotton placed in the bottom of the jars. Ordinary catheters (rubber) can be preserved dry or suspended in the same manner.

Directions for Preparing Catgut.—Unchromicized Catgut.—(*a*) Keep in ether in a tightly stoppered bottle for thirty days. Shake container daily. Change the ether at the end of the first fifteen days.

(*b*) Keep in the following solution for one month, transferring to another jar. Alcohol, 95 per cent., 1 ounce; bichloride of mercury, 1 grain. At the end of thirty days transfer to alcohol, 95 per cent.

(*c*) **Storage Solution.**—Iodized solution. Can be kept in this solution indefinitely. Iodoform powder, 1 ounce; ether, 5 ounces; alcohol, 14 ounces. As solution evaporates add ether until all iodoform powder at the bottom of the jar has been dissolved.

Chromicized Catgut.—In ether for thirty days, changing at the end of the fifteenth day. Shake container daily.

Solution A.

(*a*) To mix chromic acid solution for catgut: Chromic acid, one part; distilled water, five parts, dissolve carefully.

Solution B.

(*b*) Take solution A, one part; glycerin, sterile, five parts.

Note.—Pour solution A into solution B, slowly stirring all the time.

(*c*) Take solution B and soak catgut from twenty-four to thirty-six hours, according to resistance desired. Twenty-four hours resist absorption for seven to fifteen days. Thirty-six hours resist absorption for fifteen to twenty-five days.

(*d*) Take catgut out of solution B, rinse quickly in sterile water to free from the chromic acid solution. Stretch and rub quickly with a hard, sterile towel. Wind on glass rods or slides and preserve in the following for thirty days: carbolic solution, 95 per cent., one part; glycerin (sterile), five parts.

(*e*) At the end of thirty days keep in a storage of iodized solution.

Preparation of Silkworm Gut.—Place in coils by winding four strands around two fingers and twisting ends around the coil three times. Place coils in a piece of gauze, attaching a forceps and sterilize for forty-five minutes. Preserve in the following solutions for: Bichloride of mercury, 1 to 2000; phenol solution, 5 per cent. Purchase hard-twisted sewing machine silk, as it is the strongest made.

Preparation of Horsehair.—1. Scrub thoroughly with green soap and hot water. This should be done away from the operating room as horsehair may contain tetanus bacilli.

2. Boil for sixty minutes in a 1 per cent. sodium bicarbonate solution.
3. Change the water and allow to boil for another ten minutes.
4. Immerse in ether for twenty-four hours to remove fat.
5. Wind in coils of four strands each and for final sterilization boil forty-five minutes.

6. Preserve in any of the following solutions: Bichloride of mercury, 1 to 2000; carbolic acid, 5 per cent.; alcohol, 95 per cent.

Preparation of Gutta-percha.—1. Cut gutta-percha into squares 6 x 6.

2. Disinfect a glass table porcelain tray or platter.

3. Take a square piece of the rubber protective and place it smoothly on the surface.

4. Have in readiness a basin of cold water (sterile), green soap, bichloride of mercury, 1 to 500, and a phenol solution, 5 per cent.

5. Scrub up hands surgically clean and wear sterile gloves.

6. Scrub tissue well on both sides with brush and green soap.

7. Place in a basin of cold sterile water.

8. Then transfer to basin of bichloride of mercury, 1 to 500, to remain twenty minutes.

9. Then transfer to basin of phenol solution, 5 per cent., for another twenty minutes.

10. Change gloves to another sterile pair.

11. Place protective between folds of gauze and keep in a storage solution of boric acid, 4 per cent.

12. Cigarette drains must be handled carefully, as they tear easily.

13. Make up not more than two dozen at one time.

Preparation of Rubber Tubing.—1. Scrub well with green soap and water to remove all white coating that is present.

2. Boil for ten minutes in a 1 per cent. sodium bicarbonate solution.

3. Scrub again if any of the white coating remains.

4. Roll in a coil and place in a jar of cold water and allow to sterilize by boiling for forty-five minutes.

5. Preserve in alcohol, 95 per cent.; bichloride of mercury, 1 to 1000; formalin solution, 1 to 1000.

6. Resterilize and change the solution once weekly.

Note.—All glass drainage tubes are taken care of in the same manner.

Bartlett's Method of Preparing Catgut.—1. The strands are cut into convenient lengths, say thirty inches, and made into little coils about as large as a silver quarter. These coils in any desired number are then strung like beads onto a thread so that the whole quantity can be conveniently handled by simply grasping the thread.

2. The strings of catgut coils are dried for four hours at the following temperatures: 160, 180, 200, 220°, one hour each, the changes in temperature being gradually accomplished.

3. The catgut is placed in liquid albolene, where it is allowed to remain until perfectly "clear," in the sense that the term is used in the preparation of histological specimens. This is usually accomplished in a few hours, though it has been my custom to allow the gut to remain in the oil overnight.

4. The vessel containing the oil is placed upon a sand-bath and the temperature raised during one hour to 320° F., which temperature is maintained for a second hour.

5. By seizing the thread with a sterile forceps the catgut is lifted out of the oil and placed in a mixture of iodin crystals, one part in Columbian spirits (deodorized methyl alcohol), one thousand parts. In this fluid it is stored permanently and is ready for use in twenty-four hours; the thread is then cut and withdrawn.

DISINFECTION OF SURGICAL DRESSINGS.

Manufacturers have produced many high-pressure steam sterilizers for the disinfection of surgical dressings, which are thoroughly reliable.

It is necessary only to place the dressings to be sterilized in suitable containers and to carry out the directions which come with the sterilizer in use in order to secure perfectly sterilized dressings.

The dressings should be handled with the greatest care, to guard against contamination at all times, because persons who are careless in the manipulation of dressing material before sterilization are not likely to use the necessary care of the same materials after sterilization has been accomplished.

It is important to place the various articles in convenient bundles in order to reduce the likelihood of contamination as well as to reduce unnecessary waste.

Gauze pads should be carefully folded in case they are to be used for sponges, or for tampons or for pads to be used in performing abdominal sections, in order to prevent the ravellings from remaining in the wound.

The pads should be placed in uniform bundles and these folded in pieces of muslin or in towels folded so as to completely protect the contents against contact infection. The cover should be held in place by means of pins, and the size, number and kind of dressing should be noted on the cover by means of a lead-pencil, which will not be erased during the process of sterilization.

These bundles are then packed loosely into a metal container so constructed that it does not interfere with the steam being forced through the dressings.

It is wise to place a glass tube containing substances which change color upon being heated to 100° C. in the center of the bundles, in order to be certain that all portions of the package have been touched with live steam.

Half an hour will suffice to sterilize surgical dressings in an apparatus containing high-pressure superheated steam, but it is better to leave the dressings in the sterilizer at least one hour and then to turn off the steam and permit the heat of the apparatus to accomplish thorough drying of the dressings.

The same method will suffice for the sterilization of towels, gowns and operating suits.

These should also be placed in bundles and covered with muslin covers or they may be placed in muslin bags properly labelled and passed through the sterilizer.

Resterilizing Used Dressings.—Before the great war many hospitals destroyed all dressings after they had been once used. This resulted in an enormous waste of material, but for the sake of being absolutely safe, and because in most instances the cost did not fall upon the person who wasted the material, little attention was paid to the possibility of eliminating this item of waste.

During and since the war many hospitals have proved the safety and the economy of resterilized dressings.

Usually only dressings which have not been directly soiled with pus are resterilized. These dressings are first washed with cold water until they are free from blood, then they are boiled for half an hour in a steam laundry machine, in which the water is kept at the boiling-point by the forcing of live steam through the apparatus for half an hour.

Then the dressings are placed in a centrifugal drier, which removes the greater portion of the water. They are then placed in a drier heated to a high temperature by means of iron tubes carrying superheated steam. Then these dressings are sterilized on two or three successive days, according to the method described above. This method is known as fractional sterilization. The method is safe even if dressings are resterilized which have been saturated with pus during their previous use, but it does not seem wise to save such dressings for fear of harm coming through carelessness on the part of some member of the personnel.

In institutions in which resterilization is practised it is wise to purchase a good quality of gauze, because this can be resterilized many times while the poorer qualities speedily become stringy and useless.

Of course, the muslin covers used to protect dressings, towels, aprons, etc., must be sterilized with the same care as their contents, although this is not necessary theoretically, because these are subjected to the sterilization each time their contents undergo this process; but the nurse or other person preparing dressings should not handle anything which has been used in the operating room unless it has previously passed through the laundry except the material be new and have not come in contact with anything which might cause contamination.

ANESTHETICS AND ANESTHESIA.

By E. R. SCHMIDT, B.A., M.D.

Introduction.—From the earliest practice of the medical art, the relief of pain has been one of the principal efforts of the physician. His primitive attempts varied from the inhalation of fumes to the use of weird incantations and hypnotic spells. These eventually led him to the discovery of ether, chloroform and nitrous oxide gas. To this trio more recent years have added a variety of other more or less efficient anesthetics by which the field and scope of anesthesia have been steadily enlarged until today they have become an essential factor in surgery. Under their benign influence not only has incalculable human suffering been alleviated, but the science and skill of the modern surgeon has mounted to its present high level.

With the discovery of ether, chloroform and nitrous oxide, general anesthesia was established. Ether has enjoyed a much wider use than any other single anesthetic. Chloroform was much more popular in England and on the continent, than in the United States; however, there has been a decline in its use abroad and ether has been substituted. The reason for the employment of chloroform in the United States is explained by the fact that students are generally taught that it is the anesthetic of choice in obstetrical practice, and having thus become accustomed to its use they are disposed to continue it in their general surgery. However, the fact that our medical schools are insisting upon a year's internship in some good hospital will undoubtedly reduce the amount of chloroform employed.

With the work of Reclus local anesthesia had its beginning. It rather slowly won its way at first, but during the last two decades improved methods of administration have added greatly to its popularity and enlarged its sphere of usefulness. In skilled hands local anesthesia will suffice for almost any operation.

The results of the War on anesthesia have not been marked. Local anesthesia has been used with greater freedom. There have been some new appliances developed for the administration, suitable for emergency work and under the circumstances that existed, but whether they will find a place in civil practice is yet to be seen.

GENERAL ANESTHETICS.

Anesthetics are for general or local effect and their combined use is not unusual in modern practice. General anesthesia is a state of unconsciousness, with more or less complete loss of the perception of pain and relaxation of the voluntary musculature, produced by the inhalation of ether, chloroform or nitrous oxide gas. Each of these anesthetics differs slightly from the others in its effect. It is a well-known fact that nitrous oxide and oxygen do not cause the complete relaxation of the voluntary musculature that attends the administration of ether or chloroform. This is especially noticeable in abdominal operations, and in setting fractures.

Ether.—Ether is volatile and inflammable, and the vapors, which are about two and a half times as heavy as air, are dangerously explosive when mixed with air. It is soluble in water (1 to 10) and readily soluble in alcohol. It is the anesthetic *par excellence*, and its use is more general than that of any other anesthetic agent. In using ether, one must be certain that it contains as few impurities as possible. Some of these impurities are alcohols, peroxide, aldehydes, acids and fusel oil. These with the exception of alcohol increase the irritation to the mucous membrane of the respiratory tract. It is impossible to test each package before using it, but it is possible to obtain ether free from these impurities from a reliable chemical manufacturer. However, the fact that it has been obtained from a reliable firm does not indicate that no attention need be paid to the ether. One must always be guided by the results. The amount used, the course of the anesthesia and the after-effects, such as nausea and gas pains, are a good index to its value.

Ether depresses all parts of the central nervous system, causing loss of sensation, loss of consciousness and abolition of the reflexes. The vital centers of the medulla are involved very late in the poisoning, making its use much safer than that of any other anesthetic. The respiration is affected first. Later there is a depression of the vasomotor center and consequent fall of blood-pressure. Ether does not produce a marked effect on the heart. Its first action is a moderate reflex stimulation, but in poisonous doses it depresses the heart.

The irritating action of the ether vapor on the mucous membrane of the respiratory tract and on the kidneys is a well-known fact. With the careful administration, that prevents an over-concentration of the vapor, this irritating action on the respiratory tract can be reduced a good deal, and also by using as small an amount as possible the renal irritation will be lessened if not avoided.

Chloroform.—Chloroform is a heavy, clear, colorless and mobile liquid, of a characteristic odor and a burning, sweetish taste. It is but slightly soluble in water (1 to 200), but is miscible in all proportions with alcohol. It rapidly deteriorates under the influence of heat, light, and air. Hence it should be stored in a cool, dark place, in well-stoppered brown bottles.

Under chloroform the anesthetic state is more dangerous than with ether, as there is a gradual, but progressive, fall of blood-pressure even if the administration is carefully managed. The fall is due to depression of both the cardiac muscle and the vasomotor center. The respiratory center is also depressed, but later than the vasomotor center and the cardiac muscle, so that if respiration ceases, resuscitation is more difficult than when a like accident occurs under ether.

The irritant action on the kidneys and mucous membrane of the respiratory tract is about the same as with ether. There may be a delayed poisoning, due to prolonged administration, which may occur several days later. This produces a fatty degeneration, especially in the liver. The irritant action of chloroform is especially marked in the first stage, when most of the fatalities occur. The use of morphin and atropin preliminary to the anesthesia reduces this danger.

Ethyl Chloride.—Ethyl chloride was first used by Hegfelder in 1848. It is a colorless, volatile liquid, having an agreeable odor and a sweetish, burning taste. It induces anesthesia promptly, but, like chloroform, the danger of stoppage of the heart and the depression of the vital centers limit its use.

The pulse and respiration are at first accelerated, but when the stage of anesthesia is reached they should be normal. The induction is rapid, usually two or three minutes sufficing. There is very little excitement. Muscular relaxation is not as complete as with ether or chloroform. Too concentrated vapor is dangerous, as respiration may cease and the diaphragm go into a state of spasm. Prolonged administration lowers blood-pressure, causes cyanosis and asphyxia, and may produce death from respiratory failure.

Its use as an anesthetic is safer than that of chloroform but not as safe as ether. For short operations it is a quick and pleasant anesthetic.

Nitrous Oxide and Oxygen.—Nitrous oxide has been used alone as an anesthetic, but in combination with oxygen it has become much more popular. Nitrous oxide is a colorless gas. It has a pleasant odor and a sweetish taste. It should contain 95 per cent. N_2O and no solids, other oxides of nitrogen or organic matter. It is stored in steel cylinders of various sizes in which it has been liquefied under pressure.

The anesthesia induced is rapid and pleasant. There are no definite stages, as in ether and chloroform, and the patient passes quite rapidly into a state of surgical anesthesia. By varying the amount of nitrous oxide and oxygen given, the depth of the anesthesia can be regulated. The elimination through the lungs is quite rapid, so that a patient deep in anesthesia will soon awaken if given oxygen or air. The percentage of nitrous oxide is gradually increased from 2 or 3 per cent. at the beginning to 10 per cent. as the case may demand. The longer the anesthesia lasts the greater should be the percentage of oxygen.

The muscular relaxation in nitrous oxide and oxygen anesthesia is not as complete as with ether or chloroform, hence it is less desirable for abdominal or fracture work. Crile believes that it produces less shock, less nausea, and less lowering of vital resistance to infection than does ether.

The administration of morphin previous to the anesthetic, or using ether with the nitrous oxide and oxygen, will aid in procuring muscular relaxation.

The striking phenomena during its administration are asphyxia, stertorous respiration, cyanosis and even convulsions, dilatation of the pupils, rapidity of the heart, and swelling of the tongue.[1] Slowness of the heart is a danger sign. If nitrous oxide causes death, it does so by asphyxia, or by asphyxia and cardiac inhibition.

Mixtures.—Mixtures were introduced in an effort to reduce the mortality due to ether and chloroform. Schleich said that the further the boiling-point of an anesthetic was below the human temperature the less could be introduced into the body by inhalation. With the boiling-point about 98.5° F. the lungs can regulate the elimination, so that about as much is exhaled as is inhaled. When the boiling-point is about 149° F., as in the case of chloroform, more is inhaled than is exhaled and anesthesia is rapid; an excess is readily accumulated, so attempts were made to secure mixtures with a boiling-point that would give an ideal anesthetic.

Ether and Chloroform.—These may be used in varying proportions. Hewitt employs a mixture of two parts of chloroform and three parts of ether. Three parts of ether and one part of chloroform, constitute the Vienna mixture.

Alcohol and Chloroform.—By adding alcohol to the chloroform, Sansome thinks the evaporation of the chloroform is reduced, and, as a result, there is less concentration. One part of alcohol and four parts of chloroform are used.

Alcohol, Chloroform and Ether.—This may be used as a mixture of one part of alcohol, two parts of chloroform and three parts of ether. Its action is that of chloroform and ether. The materials do not evaporate at the same rate, so that one does not know how much of either the patient is inhaling.

Billroth's mixture consists of one part of alcohol, one part of ether and three parts of chloroform.

Schleich's Mixture.—

Solution No. 1 (by Volume).

Chloroform	℥iss
Petroleum ether	℥ss
Sulphuric ether	℥vi

Solution No. 2.

Chloroform	℥iss
Petroleum ether	℥ss
Sulphuric ether	℥v

Solution No. 3.

Chloroform	℥j
Petroleum ether	℥ss
Sulphuric ether	℥ij

No. 1 is for light anesthesia, No. 2 for medium and No. 3 for deep anesthesia. Petroleum ether has no anesthetizing power. Meltzer has shown that it is dangerous and tends to paralyze the respiratory muscle. The use of mixtures has never gained a wide popularity.

[1] Hewitt: British Med. Jour., February 18, 1899.

Preparation of the Patient for Anesthesia.—An operation is just like a chain and the results that the surgeon obtains are dependent on the weakest link in his chain. Every patient should have preparation for an operation, and especially if a general anesthetic is to be given. In an emergency where there is immediate surgical intervention, this is oftentimes impossible. The preparation should not be too prolonged unless there is some special reason, as in a very toxic hyperthyroidism, where the preparation for operation may include preliminary treatment extending over some time. Prolonged preparation has a bad effect on the patient, as there is always an operation staring him in the face.

The following routine has been found very successful at the Augustana clinic. A careful history and physical examination are made and recorded. The physical examination should be made the day before operation, so as to be certain that nothing new has developed. The urine is examined very carefully for albumin, sugar, diacetic acid, casts and blood. A red and white blood-count is made, the percentage of hemoglobin determined and the systolic and diastolic blood-pressure taken and recorded. The afternoon before the operation the patient is given a warm bath if the patient's condition permits it. In order to clean the gastro-intestinal tract, early in the afternoon preceding the operation, oleum ricini (two ounces), either in the foam of beer or orange-juice, is given. It is given early so that the effects of the cathartic will be over early in the evening and the patient secures a good night's rest. Of course, in acute abdominal conditions one should never give any cathartic. The following morning the patient receives a soapsuds enema.

If the patient has been on a full or modified diet, the evening meal preceding the operation is limited to broth. The next morning no food is taken before the operation. If there is food in the stomach, or, in cases of obstruction, when there is liable to be some retention of food, the stomach is thoroughly washed out with water at a temperature of 105° to 108° F.

In operations that may be prolonged and in thyroidectomies, the patient receives morphin, grain $\frac{1}{4}$, and atropin, grain $\frac{1}{100}$ one-half hour before commencing the anesthesia. This permits a prolonged administration of the anesthetic. Less of the anesthetic will be used and the patient will take it better. Also in alcoholic and very robust patients morphin and atropin aid the anesthetic. The fact that morphin and atropin have been administered to the patient should be recorded, so that the anesthetist is aware of it, as the pupillary reaction will be changed and less anesthetic will be necessary to keep the patient under.

Anesthetist.—The anesthetist should be a medical man if it is possible, or a carefully trained woman, preferably a nurse. The best anesthesias are conducted by women at the present time, because it is possible to select women with the highest degree of intelligence and judgment for this work, while medical men possessing these qualities can almost never be induced to elect anesthesia as a specialty. Unless the person giving the anesthetic makes a profession of this work the anesthetic may be poorly given and the patient suffer as a consequence.

Dr. Price defines an anesthetic as an agent by which the patient is carried to the edge of death and held there while the surgeon does his work. To accomplish this requires skill, knowledge and practice. There is no doubt but that a layman can learn to administer an anesthetic, and in the majority of instances do it very well. While in France the author knew a medical corps sergeant who was able to procure excellent anesthesia with any kind of an anesthetic. He had administered anesthetics many thousand times and studied the subject thoroughly from every angle. But to give an anesthetic is only a part of the task.

The personal bearing of the anesthetist, his confidence in himself, his method of preparing for work, help a great deal toward a successful anesthesia. The anesthetist must be able quickly to understand his patient. A young boy or girl must be differently handled from a man or woman. The patient must not be frightened. All these particulars noted and deftly handled by the anesthetist enhance the prospect of a good result.

For emergency there should always be at hand a mouth gag, tongue forceps, artery forceps and gauze for wiping mucus out of the mouth. A towel or two should be convenient in case the patient vomits. A hypodermic, in working order, strychnin, brandy, camphorated oil and caffein citrate should be ready. A tank of oxygen, ready for administration, should be accessible. It is a good plan, when using the open-drop method of inhalation, to have another dry mask in reserve.

When women patients are being anesthetized a third person should be in the room. This is an invariable rule. It is a well-known fact that while receiving an anesthetic women may have erotic sensations, and on awakening have declared that they were raped.

After the patient is asleep it is the duty of the anesthetist to carry the anesthesia along in a way to help the surgeon as much as possible. This means he must know the operation. For instance, when the abdomen is being opened, to prevent the intestines from protruding, thus increasing shock, the patient must be relaxed and asleep. Then he uses as little anesthetic as possible, just enough to keep the patient unconscious while the abdomen is closed and the dressing put on. The patient is now almost conscious. During this time he should be kept warm, and to avoid paralysis, the arms should be prevented from hanging over the edge of the table. The patient should be accompanied by the anesthetist to his room and left in the care of a nurse.

Methods of Administration of Anesthetics.—Open-drop Method.— This is the most commonly used method. By means of a wire mask covered with two layers of gauze, so that the vapors are not too dense, ether, chloroform and ethyl chloride and the various mixtures of alcohol, chloroform and ether can be administered.

There are many masks on the market. A very satisfactory one is the Esmark mask. It is necessary that the mask when applied to the face, covers the nose and mouth, that it fits the contour of the face snugly, and that on crossing the bridge of the nose there is no pressure. The gauze should not be too thick or else the vapor may become too dense and the patient will choke and struggle. One cannot say how thick the gauze should be, because of the difference of the mesh and texture of the gauze. A very good method is to take a small piece of stockinette, such as is used for plaster-of-Paris work, slip it over the frame and then adjust the frame. Take a small piece of surgical gauze and wind it around the edges, so that it will rest easier on the face. By varying the amount of ether dropped on the mask one can regulate the density of the vapor and the depth of the anesthesia. For each administration a dry piece of stockinette and a sterile frame are used. The stockinette can be sterilized and used many times. In order to protect the patient's face and eyes a drop of sterile oleum ricini is dropped in each eye and a piece of protective tissue, which has a V cut out of the middle, so that it fits over the bridge of the nose, is put over the eyes.

Open-drop with Posture.—In the clinic at the Augustana Hospital the open-drop method with posture has been used very successfully for many years. This is especially applicable to operations on the head and neck. The patient is thoroughly anesthetized in the prone position with ether by the open-drop inhalation method. Then the patient is taken into the operating room and the head of the operating table is elevated about 35 degrees. The patient will remain in a state of surgical anesthesia for from one-half to three-fourths of an hour without further administration of ether. As an adjunct these patients receive $\frac{1}{4}$ grain morphin and $\frac{1}{100}$ grain atropin one-half hour before operation. This continuance of anesthesia is possible because, as a result of the elevation of the head, there is an anemia of the brain. This method is of great value in thyroid operations, because a small amount of ether is used and the shock is less. In other operations on the neck and head the anesthetist is removed from the field of operation. This method is used only with ether.

Intratracheal Insufflation Anesthesia (Method of Meltzer and Auer).—This method is of value when operations are performed on the head and neck. The anesthetist is out of the way and is not so likely to contaminate the field of operation. The patient is first anesthetized in the usual position with ether. When unconscious the head is dropped over the edge of the table and a flexible rubber tube, smaller in diameter than the trachea, is passed into the trachea. This should be done by one with experience, and should be under the guidance of the eye. The tube should reach almost to the tracheal bifurcation.

To supply the ether vapor under pressure one can use a foot bellows, allowing the air to pass through a container with ether. This is the simplest. A more complicated apparatus has been devised by Dr. Elsberg, of New York. An electric motor is used instead of the foot bellows to furnish the stream of air. The air before entering the trachea is warmed by passing through hot water. This supplies a constant stream of air under pressure. During expiration the lungs force the air out of the trachea around the rubber tube. Care must be taken that the pressure is not too high and that no ether is sprayed into the trachea. Ether can be administered intratracheally without a positive pressure. A very simple way is to attach to the rubber tube inserted into the trachea a long rubber tube with a glass funnel. Over this funnel a few layers of gauze are placed, and on these ether is dropped. This is very simple, and one who knows how to give ether by the drop method can readily use this.

Intrapharyngeal Administration.—Where the tubing would interfere with operations on the mouth the ether can be given intrapharyngeally. Two soft-rubber catheters are put into the nose, one on each side, and pushed back until the ends reach the pharynx. The two outer ends are connected by means of a glass Y-tube, and the long rubber tube with large glass funnel is attached. This allows the anesthetist to keep away from the field of operation and leaves the mouth empty.

Of course, where hot irons and fire are used in an operation around the neck or head, ether and chloroform are dangerous. The air passages must be kept free. If the jaw sags or the tongue drops back an aseptic assistant must hold the jaw forward. Mucus should be wiped out of the mouth. A very good precaution to prevent much secretion of mucus and to reduce the amount of ether needed is to give the patient $\frac{1}{4}$ grain morphin and $\frac{1}{100}$ grain atropin one-half hour before operation.

Intravenous Administration.—For intravenous administration, ether is used. Under the influence of $\frac{1}{4}$ grain morphin and $\frac{1}{100}$ grain atropin, the patient is brought to the anesthetic room. A needle such as is used in giving intravenous saline solutions is inserted into a vein of the forearm. To the needle is attached a rubber tube which has a glass Y-tube at its end. Two tubes are attached. One leads to a glass container, having a 5 per cent. solution of ether in normal saline; the other goes out to another container, with only normal saline. Each of these tubes has a screw stop-cock on it, so that the flow from the two containers can be shut off or regulated as desired. All the air should be out of the tubes before starting. By turning the stop-cock on the tube leading to the container with the ether in solution the anesthesia can be begun. As soon as the anesthesia is complete the flow can be decreased to just enough to keep the patient properly anesthetized. If the patient is too profoundly anesthetized, salt solution can be run in until the second stage of anesthesia returns. By regulating the flow from the two solutions the desired degree of anesthesia can be obtained.

Kuemmel says there is no postoperative headache, vomiting or nausea. He claims that it is specially efficacious in wasted, weak individuals, patients who have lost a good deal of blood and those that are extremely exhausted.

It is contra-indicated in arteriosclerosis, myocarditis, cholemia and plethoric patients. Edema of the eyelids or conjunctiva are signs for discontinuing the flow of both solutions.

This method, as in intratracheal administration, keeps the anesthetist out of the way, the respiratory passages are not irritated as much and the air passages are free for the surgeon. Usually ten minutes suffice to produce anesthesia and from 200 to 300 c.c. of the solution or about 10 to 15 c.c. of ether.

Rectal Administration.—The utilization of the colon for the absorption of ether fumes necessitates for rapid absorption an empty colon. This is accomplished by giving oleum ricini, ounces two, twenty-four hours before the operation. Twelve hours later a high soapsuds enema is given and repeated the next morning before operation. In giving the anesthetic, oleum ricini (sterile) is dropped into each eye and then both are covered with protective tissue. This is necessary to prevent any trauma during anesthesia.

Around the rectum vaselin is spread so as to prevent irritation of the skin. The jaws should be held during the anesthesia, so as to prevent the tongue from obstructing the air passage. The apparatus necessary is a rectal tube, a rubber tube leading to a wide-mouthed bottle, with a snugly fitting rubber stopper which has two perforations. Through the stopper are two glass tubes, one reaching to the bottom the other reaching just through the stopper. A rubber tube leading from a foot bellows is attached to the glass tube reaching to the bottom of the bottle. The air bubbles through the ether and becomes saturated with ether vapor. The short glass tube is attached to a tube leading to the rectal tube. The rubber stopper must fit snugly; but it should not be firmly fixed, for it acts as a safety-valve. If pressure is too high it will come out and prevent too much tension being put on the colon.

The wide-mouthed bottle, which should be at least 30 cm. deep, so as to allow the air to go through a long column of ether, should be kept at a temperature from 80° to 100° F. This can be accomplished by keeping the bottle in a water-bath and regulating the temperature of the water by a thermometer. This causes the ether to evaporate fast enough to produce anesthesia and supplies a warm, less irritating gas to the bowel. By raising and lowering the temperature of the water the ether may be made to evaporate faster or slower.

On passing the rectal tube, all the gas in the colon is let out, and by attaching the apparatus, ether fumes are sent into the colon. At first there may be some colicky pains, but as the patient comes under the influence of ether the pressure may be increased until a state of surgical anesthesia results. By supplying from time to time more ether vapor the patient is kept under. If anesthesia becomes too deep, disconnect the tube from the rectal tube and allow the gas to escape. This can be aided by making gentle pressure on the abdomen.

The amount of ether used is small, one to four ounces sufficing for most anesthesias. Anesthesia can be induced in from five to fifteen minutes.

There is less irritation of the respiratory tract, and a patient comes out of the anesthesia soon after stopping the ether vapor. Since less mucus, ladened with ether has been swallowed there will be less nausea and vomiting. For abdominal operations this method is undesirable because of the distention of the colon with ether fumes.

In head and neck operations it keeps the anesthetist away from the field of operation. In asthenic cases and bad risks, especially in pulmonary tuberculosis and chronic affections of the respiratory tract, rectal anesthesia will reduce the irritation to the respiratory mucous membrane.

Oral Administration.—Gwathmey and Karsner[1] found that general analgesia was much safer than general anesthesia. They use 50 per cent. ether in some bland oil, such as liquid petroleum. It may be sandwiched between mouthfuls of port wine, taking away the unpleasant taste. There is no deleterious effect on the stomach, and the nausea and vomiting are absent. It is used for painful dressings.

Closed Method.—The closed method of administering an anesthetic is not generally used except with nitrous oxide and oxygen. Ether has been given a good deal this way. It is said to reduce acapnia, lessen postanesthetic nausea and practically abolish lung complications. In addition the amount of ether used is much less than in the open drop method.

There are many closed inhalers on the market. The principle is the same as the one used in the Teter apparatus for nitrous oxide and oxygen. The air is exhaled into a rubber bag and then inhaled. Fresh air may be introduced at any time. During the passage of the air from and to the rubber bag the ether is added. Dr. Rice[2] furnishes the ether vapor by allowing oxygen to bubble through ether and enter into the bag.

One objection to this method is the apparatus. The more simple the thing is, the better it is. By putting a towel over the mask used in the open-drop inhalation method a semiclosed method results. Gwathmey in his book on *Anesthesia* says that in the closed method there is an anoxemia and a danger of too concentrated ether vapor. The excess of carbon dioxide stimulates respiration, and an overdose of the ether is very likely. This, of course, must be regulated by admitting free air from time to time.

With nitrous oxide and oxygen the mask is put over the face, so as to cover the nose and mouth. Nitrous oxide is run into the rubber bag and the patient breathes it in. If the patient is difficult to put to sleep the bag may be a little overdistended. In about two or three minutes the anesthesia will be completed. As the patient is going under, oxygen may be added. The amount and proportion of oxygen and nitrous oxide used will be determined by the condition of the patient. Ether may be added when the anesthesia is prolonged, or complete relaxation of the voluntary musculature is required.

Sequence Administration.—The preliminary stage with some anesthetics is annoying to patients, especially if they have to take ether a second time. To obviate this, other anesthetics have been used for

[1] British Med. Jour., March 2, 1918.
[2] American Year Book of Anesthesia and Analgesia, 1915.

the initial stage and then followed by ether. The most commonly used are nitrous oxide and oxygen followed by ether. Chloroform may be used because it is more pleasant and ethyl chloride may be employed. These are usually administered by the open-drop method. Oral analgesia and intravenous or rectal anesthesia may be used to induce the anesthesia which is then completed with ether by the open-drop method.

Choice of Anesthetic.—The choice of an anesthetic depends on several factors. The prime factor is the safety of the patient. McGrath[1] reports 49,057 anesthetics with ether and no fatalities. At the Augustana Hospital there have been over 20,000 ether anesthesias with no fatality. This makes no fatality in almost 70,000 ether administrations. There are many statistics on the mortality due to anesthetics, and they vary greatly. This variation may be due to two things: (1) the anesthetic itself, or (2) the administration of the anesthetic. Both of these conditions can be controlled. A good grade of the drug must be used and one expert in its administration must give it.

Ether is used more generally than any other anesthetic. It gives complete unconsciousness and a relaxation of the voluntary musculature. In acute respiratory diseases, chronic bronchitis, obstruction to the air passages, arteriosclerosis, hypertension and atheroma the use of ether is more dangerous. Since ether affects the respiratory center before it does the vasomotor center and cardiac muscles, it is much easier to give, and easier for a patient to recover if too much has been given.

Chloroform has a pleasant, sweetish odor and is agreeable to take. In obstetrical work it may be administered with relative safety. Because of the danger of reflex stoppage of the heart, late poisoning and the early depression of the vasomotor center it is more dangerous than ether. It has an irritating effect on the mucous membrane of the respiratory passages. It is much more dangerous in shock than ether. In acute pathological processes in the lungs, emphysema, pulmonary tuberculosis, in marked kidney diseases, in valvular disease of the heart with hypertension and myocardial disease, chloroform should not be used.

Ethyl Chloride.—Ethyl chloride has the same disadvantage for general use as chloroform. Great care must be exercised in giving it. The vapor must not be too concentrated and a semiclosed method used in its administration. It is easy to give an overdose and cause death by respiratory failure and spasm of the diaphragm.

Nitrous Oxide and Oxygen.—Nitrous oxide and oxygen combined, make one of the safest anesthetics. Because of an incomplete relaxation of the voluntary muscles it is less desirable than ether. It should not be used in plethoric patients, in myocardial disease, valvular heart disease or in any case with obstruction to the respiratory passages, severe anemia, hypertension, diabetes, and status lymphaticus. It necessitates a much

[1] Collected Papers of Staff of St. Mary's Hospital, Mayo Clinic, 1913.

more complicated apparatus, and as the gas is in steel cylinders, its transportation is more difficult. For these reasons nitrous oxide and oxygen have not been used generally except in extracting teeth, opening abscesses and in operations that are short and where muscular relaxation is not essential. It is often used in combination with ether, and, in the hands of an expert, a very safe and satisfactory anesthesia can be secured.

COMPLICATIONS.

The postoperative complications that occur are due to (1) condition of the patient; (2) anesthetic given and (3) operation performed.

If the patient is in a very poor physical condition, the anesthetic poorly given and an extensive operation performed, it stands to reason that complications will be met. Cutler and Morton,[1] using the statistics of operation at the Massachusetts General Hospital (3490 cases), came to the following conclusions regarding the predisposing factors causing postoperative complications:

1. Poor general condition; age, anemia, alcoholism, arteriosclerosis, a weak myocardium or chronic infections of the lungs.
2. Oral sepsis: carious teeth, septic tonsils.
3. Badly given anesthetic, forced, aspiration of mucus, unnecessary intubation of esophagus, vomiting on table with aspiration of vomitus.
4. Presence of septic foci.
5. Too radical operations that open, unnecessarily, pathways to the neighborhood of the lungs and the lungs themselves.
6. Operations in the epigastrium carry the added danger of lung complication through ease of vascular and lymph extension.
7. Exposure to cooling fluids or to draughts (vasomotor disturbances).
8. Postoperative pain resulting in hypostasis from poo expansion.

They further noted that 1 in every 54 patients operated upon developed postoperative lung condition and that 1 in 106 died.

There are a good many factors entering in.

The lung complications, such as lobar pneumonia, bronchopneumonia, bronchitis, pleurisy, empyema, pneumothorax, mediastinitis, pulmonary embolism, and lung abscess are most common. By giving the anesthetic carefully, using as little as is necessary and not forcing the anesthesia, there is much less irritation. Morphin and atropin will diminish the secretion of mucus and less anesthetic will be required. The treatment immediately after operation is most important. If possible, changing the position of the patient every two or three hours will prevent a hypostatic congestion. The Fowler position will also help, and the patient's head should be elevated 12 to 18 inches whenever any evidence of pulmonary irritation follows an operation. This plan of treatment almost entirely eliminates postanesthetic pneumonia.

Nausea and vomiting are chiefly due to swallowing mucus laden

[1] Surg., Gynec. and Obst., December, 1917.

with ether, but there may be some regurgitation from the duodenum. By washing the stomach the nausea and vomiting are relieved. Preventing the excessive secretion of mucus and having the gastro-intestinal tract clean will reduce the nausea and vomiting. The patient should be almost or wholly conscious when put to bed after an operation. He should be able to cough up any vomited material that might otherwise go down the trachea, and expel excessive secretions that may collect in the respiratory tract. Drinking hot water tends to dilute the mucus and wash it out of the stomach.

Anuria occurs occasionally after an operation. One must first be certain that it is an anuria and not simply an inability to void. This can be done by catheterization. Care must be exercised in catheterizing a patient, so as not to infect the bladder and produce a cystitis. If an anuria exists the fluid intake should be increased by means of hypodermoclysis, proctoclysis and water by mouth. Water is the best diuretic. Stimulate elimination through the skin by hot packs and electric lights, through the gastro-intestinal tract by means of saline cathartics, if it is permissible. In abdominal operations, cathartics immediately and for several days after anesthesia, are contra-indicated. Diuretics, such as diuretin and caffein citrate, may aid. As a final resort the capsules of the kidneys may be split. This may prove successful when all other measures fail.

Inability to void the urine after an operation is due to a reflex spasm of the internal sphincter. Increasing the fluid intake, as described under anuria, will sometimes aid. Usually there is plenty of urine secreted. Running water in the room, applying a hot pack to the perineum or allowing the patient to sit up will often correct this trouble. Giving the patient an acid, so as to increase the acidity of the urine, will cause irritation at the internal sphincter and the urine may be voided. As a last resort the patient should be catheterized. Usually one catheterization will suffice. If not the patient must be carefully watched and should be catheterized every twelve hours. Catheterization must be performed with surgical asepsis, and even then occasionally a cystitis results.

Gas pains are prevented by a thorough preliminary preparation. The gastro-intestinal tract is clean and there is no opportunity for stagnation and fermentation. Limiting the diet to broth the evening before operation is important.

Backache may be complained of by the patient. This is usually located in the lumbar and sacral regions. Dr. Dunlop[1] believes it is due to the posture on the operating table. There is a strain due to lack of support to the lumbar curve and a strain of the iliosacral synchondrosis results. Placing a small pillow under the back during operation will obviate this.

Nephritis is usually transient if the kidneys are normal. Giving the patient water to drink, preferably distilled, as soon as possible and

[1] New York Med. Jour., July 10, 1909.

continuing to force it for a time, will soon clear up this condition. If the process in the kidney is chronic, water, together with diuretics, should be employed. Diaphoretics and cathartics when indicated may be given. Usually their use is limited. Because more ether than chloroform is generally given the irritant action of ether seems to be greater. When a patient has chronic nephritis the function of the kidneys should be carefully studied before operation.

The degree to which a patient is shocked depends chiefly on the patient's physical condition before operation. A prolonged operation, with a great deal of traumatism to the tissues, exposure of and handling of the intestines, a poor anesthesia, an excessive dose of the anesthetic or exposure to cold during the operation conspire in producing shock.

This condition will be proclaimed by a low blood-pressure, poor heart action, with a weak, small and rapid pulse, pallor, cold sweat, feeble respirations. The patient may be conscious or unconscious.

The treatment consists in prevention. The surgeon must be able to judge how much he can do without shocking the patient. The operation should be as short as possible. No unnecessary trauma or handling of the intestines should be done. If the intestines are exposed they must be covered with gauze moistened in hot saline solution. If possible they should remain in the abdomen. There should be as little loss of blood as possible. The anesthetic should be given by an expert and just as little used as is required to perform the operation. Care must be exercised in choosing an anesthetic.

During the operation the patient should be kept warm on the operating table. Whole blood transfusion by the Percy method, hypodermoclysis of saline solution, elevation of the foot of the bed and application of external heat, by means of blankets, hot-water bottles, and electric lights, tend to combat shock.

LOCAL ANESTHETICS.

Local anesthesia was practised in ancient times by the inunction of various narcotics. There was little progress made in this art until the latter part of the nineteenth century.

In 1884 Karl Koller, of Vienna, demonstrated the effects of cocain as a local anesthetic before the Ophthalmological Congress at Heidelberg. Later, Merling discovered Alpha and Beta eucain, and stovain was synthetically produced by Fourneau. Since that time the scope and use of local anesthesia has slowly increased. The introduction of the syringe in 1845 by F. Rynd, of Edinburgh, contributed an impetus to this method of anesthesia.

In 1884 Halstead and in 1885 Corning demonstrated clinically the value of cocain. Hall and Halstead also demonstrated that injecting a nerve trunk caused a sensory paralysis in its course. This work was expanded by Crile, Cushing, and Matas. The development of anociassociation by Crile has given an added value to local anesthesia.

During the last two decades its use has become more general, until now, in the hands of a skilled operator, any operation may be performed under local that has been done under general anesthesia. There are none of the accidents that happen during the use of a general anesthetic and no postanesthetic complications except vomiting and pneumonia. The only disadvantage is the fact that the patient is conscious and may become alarmed. However, this factor together with a perfect injection depend on the skill and ingenuity of the operator. Some men are so skilled, can so dominate the consciousness of their patients that they are able to do almost any operation. Farr[1] cites 77 cases in children, and almost every part of the body was operated upon. He says the psychic element is not so important, and sometimes restraint is necessary. The anesthesia must be complete and the surgical technic refined.

The scope of local anesthesia has been broadened by the knowledge that viscera innervated by purely visceral nerves are insensitive, and sensation exists only in those that receive branches from the somatic nerves. Lennander[2] shows that the parietal peritoneum is sensitive to pain but not to touch. The intestine, stomach, edges of the liver, mesentery, gall-bladder, urinary bladder, kidney parenchyma, lung, anterior wall of the trachea, testicle and epididymis are insensitive, but the coverings of the testicles and epididymis are sensitive.

Action.—Local anesthetics produce anesthesia over a limited area in three ways: (1) by an anemia of the capillaries supplying the nerve endings; (2) by direct action on the nerve-endings; (3) by direct action on the nerve fibers. It has been shown that by injecting normal saline under pressure, anesthesia will result. No doubt, in different local anesthetics, their effectiveness depends on whether they act in all three ways or in only one or two.

The action may be intensified in various ways. Corning, and Oberst, of Halle, by applying a tourniquet proximal to the area anesthetized, increased the anesthesia because of the increase of the anemia. Braun used adrenalin with his injecting solution and prolonged the anesthesia, due to the greater anemia.

It is to Schleich that we owe the introduction of weaker solutions and a greater use of local anesthesia. There is thus less danger of poisoning and a greater area is anesthetized. Reclus, Schleich, Braun, and Puchet showed clinically that a large quantity might be injected, but that $1\frac{1}{2}$ to 3 grains of cocain is the maximum.

Preparation of Solutions.—As a result of the work of Schleich, weaker dilutions of the agent are used. It is preferable to use salt solution as the diluent, for if the solution is not isotonic there will be an irritation and traumatism of the tissues. Following the injection there will be a reaction.

The solution prepared must be sterile. Some drugs, such as cocain, break down upon heating, so a sterile solution must be prepared by dis-

[1] Interstate Med. Jour., February, 1919.
[2] Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1902, Bd. x, Hefte 1 und 2.

solving the sterile cocain in sterile water. Fresh solutions should be prepared often, as it soon deteriorates. Stovain, novocain and alypin may be boiled and a sterile solution obtained.

The addition of adrenalin intensifies the action by increasing the local anemia, and thus reduces hemorrhage during the operation. The disadvantage of using adrenalin is that there may be delayed bleeding. Usually ten minims of a 1 to 1000 solution of adrenalin to 100 c.c. of solution is sufficient.

T. Sollman[1] finds the alkalinization increases the efficiency from two to four times. The anesthetic salts may be mixed with an equal volume of 0.5 per cent. sodium bicarbonate solution without loss of efficiency and one-half of the anesthetic is saved.

Eggleston and Hatcher[2] find that the toxicity of the different drugs varies and depends on the rate of their absorption and elimination from the system. Using epinephrin delays the absorption, gives the system more of a chance to eliminate and so reduces the toxicity. The elimination is due to destruction of the drug in the liver.

They find that death is due to paralysis of the heart and respiratory center. By artificial respiration and intravenous injection of epinephrin the patient may be carried along until the system has had a chance to eliminate some of the drug. They advise using epinephrin in solution of alypin, apothesin, beta-eucain, nervanin, procain (novocain) stovain and tropacocain, as it delays the absorption and allows time for destruction of the poison. It prolongs the anesthesia and reduces the amount of the anesthetic required.

Morphin and Atropin.—As an adjunct to all local anesthesia the use of morphin and atropin is indicated. By depressing the higher centers the perception of painful stimuli is not so acute and an anesthetic that might have been a failure is a success. It is also easier for the surgeon to dominate the situation and gain the confidence of the patient. For adults $\frac{1}{4}$ grain of morphin and a $\frac{1}{100}$ grain of atropin are used. For children the dose is reduced to $\frac{1}{16}$ or $\frac{1}{12}$ grain of morphin and $\frac{1}{150}$ to $\frac{1}{200}$ grain of atropin.

Cocain.—Cocain is derived from several varieties of cocoa. It forms colorless prisms and has a slightly bitter taste. It is slightly soluble in water (1 to 600), freely so in alcohol (1 to 5). In fixed oils it is soluble, but insoluble in petrolatum and lard. The hydrochloride that is most commonly used, is freely soluble in water. On boiling it is hydrolized into egonin, benzoic acid and methyl alcohol.

If too large a dose is used or a person has an idiosyncrasy for it, symptoms of poisoning develop. At first there is a stimulation of the different segments of the central nervous system. The exaltation in the brain has usually passed into depression by the time the spinal segments are reached, so that there may be a mixture of depression and stimulation. Muscular irritability, loss of sense of fatigue, increased psychic activity and insomnia are evidence of stimulation.

[1] Jour. Am. Med. Assn., January 26, 1918.
[2] Ibid., October 25, 1919.

Somnolence, stupor and coma show that depression has set in. Respiration may be of the Cheyne-Stokes variety, and is usually quickened. Later, respiratory paralysis may set in. The heart-rate is increased at first but later becomes weak, and the blood-pressure falls as vasomotor paralysis appears.

Cocain, in addition to its anesthetic effect is a vasoconstrictor and is often used in nasal work to shrink the mucous membrane.

Eucain.—There is an alpha and a beta eucain. The beta compound is less irritating and toxic than the alpha. It has the same anesthetic action as cocain, but instead of vasoconstriction it produces a slight vasodilatation. The salts of eucain are fairly soluble in water, especially the hydrochlorate and the lactate. It is a synthetic preparation and derived from benzoyl. Its action is said to be slower than that of cocain or novocain but after its action has begun the anesthesia lasts as long. It is far less toxic than cocain.

Tropacocain.—Tropacocain is derived from the same source as cocain. It is benzoyl tropin and its action is similar to cocain. However, its induction of anesthesia is quicker and does not last as long as cocain. It is about one-half as toxic. It has no vasoconstrictor or vasodilator action. It has been used for the most part in spinal anesthesia.

Stovain.—Stovain is also a benzol derivation. It is readily soluble in water and has been used a great deal in spinal anesthesia. It can be heated to 120° C. before it begins to decompose. There is some irritating action on nerve tissue, and the anesthetic effect is less intense and of shorter duration than that of cocain. When injected into tissues at first there is a slight, burning pain, then anesthesia follows. Following the anesthesia there is often an inflammatory reaction and if strong solutions up to 10 per cent. are used there may be marked tissue necrosis.

Novocain (**American Procain**).—Novocain hydrochloride was introduced by Einhorn in 1905. It is less irritating and toxic than cocain or eucain. It is soluble in water in equal parts and 1 to 30 in alcohol. Heating to 120° C. will not decompose it, and it may be kept in solution for a long time. In anesthetic action a 1.25 per cent. solution has the same effect as a 1 per cent. solution of cocain, and has about $\frac{1}{6}$ of the toxicity of cocain. The anesthetic action will not last as long as cocain. However, by adding adrenalin its action is intensified so as to make it equivalent to cocain and while the action is not so rapid it may last longer. There is no vasomotor disturbance, irritation of the tissues or postanesthetic inflammation. In the eye its action is much slower, but it does not damage the cornea as does cocain.

Alypin.—Alypin, a derivative of the benzoyl group, was introduced by Imperes. It is readily soluble in water and alcohol and is not decomposed by boiling. It is a white, crystalline powder. The anesthetic power is about the same as that of cocain. Injection of alypin causes a slight burning sensation and some hyperemia. Its anesthetic action is of shorter duration than cocain, but the addition of adrenalin will prolong its action. There is less irritation and toxicity than with cocain.

In the eye there is no drying of the cornea, no dilatation of the pupils nor changes in accommodation and tension. Cocain in the hands of the skilled has proved far superior. Drs. Bransford Lewis and Willy Meyer recommend alypin in the genito-urinary tract. Dr. Meyer uses a 2 per cent. solution for instillation.

Anesthesin.—Anesthesin has found its greatest use in topical application. It is a fine, white crystalline powder and melts at 90° C. Prolonged boiling will cause decomposition. It is non-irritating and almost non-toxic. It is insoluble in cold water, but slightly soluble in warm and hot water. It is soluble in alcohol, ether and benzin, but less so in fatty oils.

If left on a surface undisturbed its anesthetic action reaches its maximum in ten minutes and lasts for hours. This has a varied use in otalgia, painful open wounds, continued vomiting, itching, vesical and rectal irritations and ulcers.

Apothesin.—Apothesin is an American product. It occurs in small, snow-white crystals and melts at 137° C. It dissolves in alcohol and water and is slightly soluble in acetone and ether. There is very slight irritation and no toxic effect. The action is quite rapid and lasts for some time. During the war, because of a scarcity of foreign-made local anesthetics, apothesin came quite widely into use. It has been a very efficient agent, and in its toxicity and slight irritating effects it resembles novocain.

Quinine Salts.—The hydrochloride of quinine and urea is the most soluble of the quinine salts. Its anesthetic effect is not so rapid in infiltration and in topical application, but its effect lasts a great deal longer than cocain, novocain, or eucain. There is no diffusion of the anesthetic action, and vasodilatation favors capillary oozing. Following the injection and depending on the concentration there is some induration. As a local anesthetic agent it can be used for almost any operation. The serious drawback is this hard swelling and a capillary oozing from the wound. This prevents rapid healing by first intention. Dr. F. W. Parham[1] calls attention to tetanus following the injection of quinine solution for malaria. Dr. C. W. Allen, discussing it in his book on *Local and Regional Anesthesia,* thinks there is a necrosis of the tissue with a suitable place for the tetanus spore to develop; because of low toxicity and of long-lasting anesthesia the quinine salts are often used in local anesthesia.

Dr. C. W. Allen,[2] quoting from Piquaud and Dreyfus,[3] says that cocain is the most powerful of all local anesthetics, but its high toxicity renders it dangerous; a safe dose should not exceed 14 to 15 cg. in 1 to 200 solution, care being taken to maintain the recumbent position during and after its use. Dr. Allen says further:

"Beta-eucain appears to present no advantage over cocain; it is equally as toxic, much less anesthetic, and more irritant.

"Alypin should be proscribed in view of its toxicity and irritability qualities.

[1] New Orleans Med. and Surg. Jour., October, 1913.
[2] Loc. cit.
[3] Jour. Phys. et Path gén., January, 1910.

"Stovain presents considerable advantage over cocain; it is two times less toxic, and a safe dose is placed at 30 cg. of a 1 to 200 solution.

"The irritant action following its use and its weaker anesthetic power can be largely overcome by using it in normal salt solution and in slightly greater strength.

"Novocain appears at the present time the most commendable of local anesthetics; its feeble toxicity permits large doses to be used without inconvenience; it has considerable anesthetic power; it is non-irritant and not a vasodilator. The only inconvenience is that its action is comparatively a little shorter than cocain, but this can be overcome by the addition of adrenalin, which produces a prolonged anesthesia of slightly more marked degree without increasing its toxicity."

Methods of Administration.—Topical Application.—For anesthetizing mucous membranes topical application may be used. On unbroken skin the local anesthetic has no effect. For this kind of an anesthesia the strength of the solution is greater than that used for other methods. Cocain is generally used, although Sollman[1] says that beta-eucain, alypin and tropocain are very useful. A 5 per cent. solution may be used for local application to the mucous membrane. Epinephrin should be added to the solution, about 10 mimins for every 100 c.c. of solution. Care must be exercised in its use in the urethra, for it seems that absorption here is very rapid. In nasal work the strength of solution should be 1 per cent. with the adrenalin. This method is a very excellent one as a preliminary step to injection.

Infiltration.—This method is the most widely used. Necessary for this method is a set of good hypodermic needles of various lengths and a good syringe. Many syringes have been invented, such as self-filling, those that deliver the solution under a constant pressure, etc. But a convenient apparatus consists of a syringe that is air-tight, the size varying from 1 to 20 c.c., and several hypodermic needles of various lengths.

Reclus first introduced this method. The skin should be injected first. This is done by introducing the needle into the skin itself, injecting the solution so that it is under pressure and produces wheals. By pushing the needle along and injecting the solution at a constant pressure a series of wheals are produced. When the full length of the needle has been inserted, withdraw it and reinsert it in the skin just inside of the last wheal and continue the injection. If the operation extends deeper, by means of a larger needle, layer by layer of the deeper structures are injected, so that all the structures that are to come in contact with the knife are anesthetized.

Regional Anesthesia; Bier's Intravenous Anesthesia.—This method was introduced by Bier in 1908. It is applicable to operations on the limbs when infiltration would not be successful. It is not widely used.

The limb is elevated and an Esmarch bandage put on, beginning

[1] Jour. Am. Med. Assn., January 26, 1918.

at the distal end and wound proximally. Above this bandage a tourniquet is applied. The Esmarch is removed. Another tourniquet is put distal to where the operation is to be performed. Into the veins, which have been marked, 50 c.c. of a $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of novocain solution are injected. Anesthesia will be quite rapid, but one must wait until the field of operation is anesthetized. There may be a motor paralysis in the peripheral part of the limb, but that soon disappears. Bier before closing the wound moves the peripheral bandage and loosens the proximal, so that the arteries are open, but the veins still compressed. As much as possible of the solution is washed out of the wound. If much anesthetic has been used the veins can be washed with normal saline and a good deal of anesthetic will escape through the wound. In diabetes and arteriosclerosis it is contra-indicated.

Perineural Method.—The nerve supplying the sensory filaments to the area which is to be operated has the anesthetic agent infiltrated around its sheath. This in from ten to thirty minutes will completely block all sensory stimuli. The nerve is not injured and this is a simple method of procuring anesthesia.

Endoneural Method.—Crile[1] found that by injecting cocain directly into a nerve trunk, anesthesia of the part supplied by the nerve quickly resulted. In promptness it has the advantage over the perineural method, but it can only be used in large nerves. The nerve must be exposed to be certain that the injection is made into the nerve itself. Sometimes a neuritis follows the injection. The blocking of the sensory stimuli is complete.

Spinal Anesthesia.—This method of anesthesia was introduced by Corning in 1885. Some years later it was taken up by Bier and made more familiar to the medical profession. Spinal anesthesia, as all other methods, has a place in the practice of medicine and surgery. In the hands of a surgeon who has had experience with its use it is quite efficient. Sometimes in the hands of the enthusiast its use is overdone. Oftentimes in attempting this method of anesthesia a partial failure will result and a general anesthetic must be given.

In hypertension, aneurysm, cardiac decompensation, eclampsia, nephritis, labor and arteriosclerosis it may be the method of choice. Because of the vasomotor relaxation it is contra-indicated in conditions of hypotension. In operations above the costal arch, superficial infection near the point of injection, lesions of the spinal cord, in athletic individuals and for light anesthesia, spinal anesthesia is contra-indicated. Care and good judgment must be used in the selection of patients suitable for spinal anesthesia.

Attempts have been made to regulate the height of the anesthesia by means of varying the specific gravity of the solution injected. A 5 per cent. solution of glucose, glucose solution with alcohol, using spinal fluid as a diluent, have been employed. At the present time the 5 per cent. glucose solution is used much more abroad while the tendency in the United States is to prefer spinal fluid.

[1] Jour. Am. Med. Assn., February 22, 1902.

Many different drugs have been used, cocain being the first. At the present time most of them have been discarded with the exception of stovain, tropocain and novocain. These in the experience of men who have tested spinal anesthesia widely, have the least deleterious effects. The novocain comes in what is known as tablet "A." It contains $1\frac{7}{8}$ grain of novocain and $\frac{1}{250}$ grain of suprarenin.

Orth and Müller[1] prepare their solution in the following manner: An ordinary test-tube, cork to stopper and beaker are boiled fifteen minutes in water free from bicarbonate of soda. They specify this because novocain and adrenalin preparations are chemically affected by alkalies. These utensils are then rinsed in freshly distilled water. About 3 c.c. of freshly distilled water are poured into the test-tube, boiled a few minutes and allowed to stand until ready for use. A color of a faint rose or a brownish red is the result of decomposition of the suprarenin by oxidation. Only clear and colorless solutions are to be used. When ready for use the solution is brought to the boiling-point six to eight times to sterilize. It is not boiled continuously as the active principle of suprarenin would thereby lose its effect. The solution is then poured into the beaker, from which it is drawn into a syringe. The specific gravity of this solution is approximately that of the spinal fluid, 1.008. In giving the fluid, about 7 c.c. of spinal fluid are withdrawn and mixed with the 3 c.c. of novocain solution and then slowly injected.

Barker[2] uses a solution isotonic with the blood. It consists by weight, of 5 parts of stovain, 5 parts of glucose and 90 parts of distilled water. He uses, on the average, 1 c.c. of the solution and injects it directly into the spinal canal without withdrawing any spinal fluid. It is injected very slowly. Barker does not use adrenalin.

The site of injection has varied from between the fourth and fifth lumbar to high in the dorsal region. At the present time high injections are coming more and more into disfavor, and only the low injections in the region of the lumbar vertebræ are used. It is less dangerous, and, if a higher anesthesia is desired, changing the position, using more solution and using a solution of low specific gravity will give it.

Usually the region between the third and fourth lumbar vertebræ is chosen. Whether the patient sits up or lies down depends upon the operator. The usual way is for the patient to lie on the side, flex the knees on the abdomen and the head on the chest. The region of the back is prepared with the usual surgical care. The needle is inserted in the midline and just below the spine of the third lumbar vertebra. The needle should be sharp, the bevel on the end short and the diameter about $\frac{1}{16}$ inch and 5 to 6 inches long. It may be of platinum or gold, as they are flexible and stand boiling without becoming rusty. The needle with the stylet is introduced until it suddenly seems to go easier. The stylet is withdrawn and spinal fluid will usually drop out. We

[1] A Plea for Spinal Anesthesia, St. Paul Med. Jour., July, 1917.
[2] British Med. Jour., March 16, 1912.

are now in the subarachnoid space and ready to withdraw spinal fluid to mix with the solution.

Anesthesia begins to show itself very soon in the following order: "Perineum, external genitalia, posterior surface of the thighs, legs, feet, anterior surface of the thighs, umbilicus and costal arch." (Orth and Müller.) The surgeon must be careful in each individual case to see that the field of operation is fully anesthetized before beginning. The untoward effects reported are many: headaches, ocular palsies, collapse, meningitis, retention of urine, chills, elevation of temperature, incontinence of urine, paraplegia, pains in the back and legs, nausea, vomiting, sweating, dimness of vision and dyspnea. These are unpleasant complications and can be obviated to a great degree, (1) by using a low puncture; (2) by injecting the solution slowly, so as to permit rapid absorption; (3) by using drugs which have not deteriorated. Orth and Müller[1] found that headaches and the untoward effects in the use of novocain and suprarenin occurred usually when the solution was reddish or brownish. This was due to decomposition of the suprarenin. They also insist on the use of distilled water to rule out any foreign bodies.

From statistics one finds that spinal anesthesia has a fairly high, mortality. Tuffier[2] notes three deaths in 2000. Perkins[3] finds in a series of collected cases 16 deaths in 2345 cases. Although in special cases it may be the anesthetic of choice, it cannot compare with ether for general use. It should be undertaken only by men of experience.

Paravertebral Anesthesia.—To circumvent some of the ill effects of special anesthesia, paravertebral injection of the spinal nerves has been used. Corning, in 1885, attempted to inject close to the spinal canal. Selheim, in 1905, injected the roots of the lower dorsal and the ilio-inguinal and iliohypogastric nerves. The solution usually used is 1 to $1\frac{1}{2}$ per cent. novocain with adrenalin. Some observers, especially Muroya, use a 5 per cent. gelatin with adrenalin in normal saline to delay absorption. 0.4 to 0.8 gm. of novocain is the amount that is usually needed.

The intervertebral foramina are protected by the lateral projections of the transverse processes. As the anterior and posterior roots come out of the intervertebral foramina they join, and from the anterior branch a filament runs to join the sympathetic system. The object in paravertebral anesthesia is to inject, just before they divide, so as to catch all the fibers. After determining what segments are to be anesthetized, these segments must be located on the vertebral column. After definitely locating the segments one is ready to inject. Allen[4] gives the following method for finding the point of injection: "A vertical line is drawn down the tips of the spinous processes and lateral measurements are made from this line; the free intervals between the

[1] Loc. cit.
[2] La Presse Médicale, 1901, lv, 190.
[3] New Orleans Med. Jour., January-September, 1902.
[4] Local Anesthesia, 1918, 2d edition, p. 494.

transverse processes are about one inch on each side. While the conformation of the vertebræ in the dorsal and lumbar regions is quite different this measurement holds good along the entire dorsal and lumbar regions. As the intervertebral foramina are shielded posteriorly by the lateral projections of the articular processes a point about $\frac{1}{4}$ inch farther out, making $1\frac{1}{4}$ inch from the midline, is best selected as the point of puncture, so as to enable the needle to be directed upward and inward toward the intervertebral foramina. The average interval between the transverse processes in the dorsal region is $\frac{1}{2}$ inch, while the midpoint of this space lies in a vertical line about 1 inch from the midpoint of the space above and below it.

"In the lumbar region the free space between the transverse processes is from $\frac{1}{2}$ to $\frac{3}{4}$ inch and the distance from the midpoint of one space to that of another is $1\frac{1}{4}$ inch."

Untoward effects such as one finds in spinal anesthesia have been noted. This is due to the fact that while injecting, some of the solution enters the spinal canal. Lawen and Gaza, in experimenting with epidural injections in animals, found that colored solutions entered the spinal canal and would ascend, so that care must be exercised while injecting. The injection should be made at the site of the union of the anterior and posterior branch before the branch to the sympathetic ganglia is given off. Too much pressure should not be exerted.

This method is used also in the cervical region. Braun, following the method of Heidenhain, injected in a line drawn from the transverse process of the atlas to the transverse process of the sixth vertebra. By inserting the needle straight in, the nerves can be reached and anesthesia produced. When the midline structures are involved both sides of the neck are injected.

Parasacral Anesthesia.—Over the lower end of the sacrum, just lateral to its junction with the coccyx, a long needle is inserted. This follows up the sacrum until it runs into the lowest sacral foramen. As the needle is introduced the solution is slowly injected. As each foramen is reached more solution is injected. This is continued until the solution has been injected on each side. Just before finishing, several cubic centimeters are injected between the coccyx and the rectum. This injection furnishes a sufficient block for prostatectomies and minor operations on the rectum. Novocain and adrenalin, $\frac{1}{2}$ to 1.05 per cent. is used in making this injection.

SHOCK AND HEMORRHAGE.

By JOHN W. NUZUM, B.S., M.D.

Introduction.—The importance of traumatic shock as a most serious complication attendant on a certain proportion of surgical operations and frequently associated with various wounds and injuries of the body, has led to an extensive investigation of the mysterious nature of wound shock and methods of combating the same.

The recent world war has afforded unparalleled opportunities to surgeons for the study and investigation of both shock and hemorrhage. As a direct result several of the older conceptions relative to the causation of shock must now be discarded and a standardized method of treatment has been definitely established on a sound basis. I propose to discuss briefly the various theories of the etiology of shock, together with the symptoms, diagnosis, prophylaxis and treatment.

Definition.—Shock may be defined as a general bodily state following various surgical operations and wounds characterized by a persistent low arterial blood-pressure, rapid, thready pulse, pallor, sweating and shallow, rapid respiration. Primary wound shock refers to those patients in whom the onset of the typical symptoms occurs suddenly, associated with the constant low systolic blood-pressure. Secondary shock is confined to those cases in whom all the symptoms of shock manifest themselves only after a longer or shorter period of continuous hemorrhage, exposure to cold, complicating infections, etc. All observers agree that the one common pathognomonic finding in shock is the persistent low systolic blood-pressure. Hemorrhage when severe presents a clinical picture quite similar to shock. Dr. W. J. Mayo,[1] from his wide surgical experience believes that perfect hemostasis is positive prophylaxis against surgical shock, and states there is no surgical shock with perfect hemostasis.

In both shock and hemorrhage there is an insufficient circulation of blood; in each severe damage may result to the vital cells of various essential organs; and in both conditions the essential problem is the rapid restoration of a normal blood-pressure. It is common knowledge that shock may be induced by rough handling, tearing and pulling of the body tissues, by prolonged exposure of the abdominal viscera, by traumatism to the mesentery of the bowel and by prolonged anesthesia. Numerous experimental studies of shock have been made in animals, apparently with the view of discovering a single cause for a condition now known to be instituted or aggravated by a variety of causes, at least in man.

[1] Quoted by Bissell: Surg., Gynec. and Obst., 1917, xxv, 8–22.

The Critical Level of Blood-pressure.—Fraser and Cowell[1] have reported a large series of blood-pressure determinations made in shock cases among the soldiers in France. They found that moderate cases showed a systolic pressure of approximately 90 mm. of mercury while severely shocked patients had systolic pressures varying from 40 to not more than 70 mm. With the falling arterial pressure it is very essential, from a therapeutic point of view, to know at what level in the blood-pressure scale the oxygen supply to the tissues become insufficient. It has been found that this "critical level" of systolic pressure is approximately 80 mm. of mercury and a fall below this point maintained for any considerable time results in an inadequate oxygen supply to the tissues. The nerve cells are early affected by this anemia; later the vasomotor mechanism suffers, and if the arterial pressure is not restored before too long a lapse of time no known treatment will suffice to save the patient's life.

Theories of Etiology of Shock.—*Nerve Exhaustion Theory.*—G. W. Crile,[2] as a result of extensive investigations of the blood-pressure and nerve cells in shocked animals, states that "the most vital effect of shock is the impairment of the vasomotor mechanism." He believes that exhaustion of the cells in the brain, liver and suprarenal glands constitutes shock. Crile[3] and Dolley have shown that histological changes can be demonstrated in the nerve cells of shocked animals, which they attribute to the afferent impulses reaching the nerve cells from stimuli induced by trauma, fear, emotions, etc. On this basis Crile has developed his theory of anoci-association or nerve-blocking, with which all surgeons are familiar. It should be stated that those who dispute the evidence of histological changes in the nerve cells of shocked animals claim that similar histological changes are within the limits of normal variations,[4] and that these same alterations in the nerve cells are the result of low blood-pressure rather than its cause.[5]

The Acapnia Theory.—Henderson[6] advanced the theory that shock was the result of a reduction of the carbon-dioxide of the blood, a condition known as acapnia. In support of his argument he produced a shock-like state in animals by vigorous artificial respiration. He believed that the diminished CO_2 content of the blood produced in the above manner was the prime factor in the production of shock.

Fat Embolism.—Porter, who was one of the first Americans to visit the battlefields of France in order to study shock in the front-line trenches, has brought evidence to show that shock may be produced

[1] A Clinical Study of Blood-pressure in Wound Conditions, Jour. Am. Med. Assn., 1918, p. 520.

[2] Volumes on Surgical Shock; Blood-pressure in Surgery; Anoci-association.

[3] Anoci-association, Philadelphia, 1913.

[4] Allen: Proc. Soc. Exper. Biol. and Med., 1915, xii, 96: Kocher, R. A.: The Effect of Activity on the Histological Structure of Nerve Cells, Jour. Am. Med. Assn., July 22, 1916, p. 278.

[5] Cannon, W. B.: A Consideration of the Nature of Wound Shock, Jour. Am. Med. Assn., March 2, 1917, pp. 611–617.

[6] Am. Jour. Physiol., A Series of Papers, 1908–1910.

in animals by the intravascular injection of fat or oil. In his paper on "Shock at the Front"[1] he wrote as follows: "I have myself examined more than a thousand wounded. Save a few wounds of the abdomen, in which the bloodvessels or their nerves in that great vascular region were probably directly injured, there has been no case of shock except after shell fractures of the thigh, and after multiple wounds through the subcutaneous fat. In these, closure of the capillaries by fat globules is known to take place. This is strong support for my discovery that shock may be produced in animals by injecting fat into the veins."

Porter advocated the rebreathing of expired air as a preliminary measure to improve the circulation before surgical operations in badly shocked soldiers. His plan was to increase the excursions of the diaphragm so as to pump the blood out of the great splanchnic vessels back into the heart.

Bissell[2] has observed six instances of fatal postoperative fat embolism in the necropsy service of the Mayo Clinic, and concludes that "deaths clinically supposed to be due to surgical shock are due, in so far as this experience goes, to pulmonary fat embolism and its attendant blood-pressure phenomena."

Several investigations have brought forward evidence to disprove the fat-embolism theory of shock, and have pointed out a possible danger in the rebreathing of expired air as advocated by Porter. Thus, Cannon[3] quotes: "English surgeons of extensive experience at casualty clearing stations in the recent war, who have performed many hundreds of abdominal operations on patients in all degrees of wound shock, have testified that on opening the abdomen they have not found any primary splanchnic congestion."

Furthermore, as regards the possible dangers of rebreathing expired air, "The testimony of Marshall, who as an expert anesthetist in a casualty clearing station has had large experience, is pertinent . . . the most important consideration in anesthetizing patients suffering from hemorrhage or shock is to *avoid anything* in the *nature of asphyxia;* indeed, that if such a patient becomes cyanosed he loses ground that can hardly be recovered."

Finally, McKibben[4] reports the presence of fat in the vessels of all animals examined whether shocked or not and no quantitative or qualitative differences were noted between the fat in the vessels of shocked animals and those of normal animals.

Suprarenal Exhaustion.—It is known that the medullary portions of the suprarenal bodies possess a blood-pressure-raising constituent, and the theory has been advanced that exhaustion of the glands leads to shock with consequent low blood-pressure. As opposed to this

[1] Shock at the Front, Boston, 1918.

[2] Pulmonary Fat Embolism: A Frequent Cause of Postoperative Surgical Shock, Surg., Gynec. and Obst., 1917, xxv, 8–22.

[3] Statement by Wallace, Fraser and Drummond: Lancet, London, 1917, ii, 727.

[4] A Note on Intravascular Fat in Relation to the Experimental Study of Fat Embolism in Shell Shock, Am. Jour. Physiol., 1919, xlviii, 331.

theory, Mann[1] has shown that total suprarenalectomy does not produce the state of shock.

The Cardiac Failure Theory.—Arguments that the heart itself is the offending organ in shock would seem to be disproved by the repeated observations on the slowing of the rapid heart action and the resumption of its normal function following massive transfusion of blood in patients suffering from shock due to hemorrhage.

Shock as Exemia.—After an intensive study of shocked troops on the battlefields, Cannon[2] offers an additional conception of the causation of shock which demands critical analysis. He believes that the low blood-pressure of shock is explicable as a consequence of blood being stagnant in some part of the vascular system, a condition to which he has given the name of "exemia," meaning "drained off blood." This exemic blood is not in the abdominal veins as formerly supposed, but is stagnant in the capillary beds. He has demonstrated that the capillary blood in shock may be so concentrated that a cubic millimeter by actual count may contain as high as two and one-half million more of red blood cells than simultaneous venous blood counts.

Furthermore, in coöperation with Bayliss, Cannon has shown that shock may result from tissue injury. Thus "the crushing of the muscles of the hind leg of an animal is followed by a fall of arterial pressure reaching a shock level in about one hour. This effect occurs even though the nerves to the leg are severed; it is therefore not of nervous origin. If the bloodvessels (iliac artery and vein) of the leg are tied and the muscles injured by blows the pressure drops only after the blood flow is restored. And if a shock pressure is produced by muscle injury, tying the vessels may be followed by a steady rise of arterial pressure to the normal level."

As a result of these important observations, Cannon has arrived at the following conception of wound shock: "There are primary wound shock with rapid lowering of arterial pressure, and secondary wound shock with toxemia and hemorrhage and subsequent lowering of the pressure."

Various causes in combination, some nervous, others chemical and each associated with a reduction of arterial pressure, and all exaggerated by hemorrhage, result in a state of collapse attended by a low blood-pressure. Sweating occurs with loss of fluids and loss of body heat. Along with hemorrhage, absorption of the toxic products contained in the tissue juices of the injured muscles effect a concentration and stagnation of the blood in the capillary beds. With the fall of pressure acidosis supervenes roughly proportionate to the drop of pressure.

The condition of the shocked man tends to become acute unless the absorption of the toxic products of muscle injury are counteracted.

[1] Shock during General Anesthesia, Jour. Am. Med. Assn., August 4, 1917, p. 371.

[2] A Consideration of the Nature of Wound Shock, Jour. Am. Med. Assn., March 2, 1918, pp. 611–617. Reports of Special Shock Investigation Committee of the Medical Research Committee of Great Britain—a series of six papers.

Operative treatment is imperative at the earliest possible moment. A shattered, useless limb must be amputated. A tourniquet should be applied as near as possible to the zone of injury and amputation done proximal to the constrictor before removal of the same. It is vital that the blood volume and blood-pressure be raised above the critical level by transfusion before the existing anemia of the nerve centers leads to a permanent paralysis. After too long a period of anemia recovery is not possible by any known method of treatment.

It is obvious, from the many diverse theories on the causation of shock and the voluminous literature relative to experimental production of shock and its clinical manifestations, that the real etiological factors still remain to be discovered. However, it must be admitted that vital information, more especially as regards treatment and prophylaxis, has accrued from the careful and tedious investigations made during the recent world war. Fat embolism does not explain all of the cases; loss of vasomotor control with stagnation of blood in the great splanchnic vessels, a theory which had gained considerable prominence, could not be confirmed by English surgeons performing many hundreds of abdominal sections on soldiers in all stages of wound shock; while Cannon's notion of stasis of blood in the capillary bed with toxic absorption of the products of injured muscle tissue has yet to be confirmed.

It seems fair to assume that each of these different factors may play a role in certain cases of shock, some instigating, others merely the result of a state of traumatic or surgical shock.

Diagnosis.—The diagnosis of surgical shock calls for but brief comment. Indeed, surgeons with but limited experience, if alert, recognize the typical syndrome in its early stages when appropriate treatment can be best instituted. The characteristic pallor, sweating, rapid weak pulse, subnormal temperature, shallow rapid breathing and a falling blood-pressure constitute a clinical picture which can hardly be misinterpreted. When the condition develops subsequent to a prolonged or severe operation, or supervenes rapidly after a severe hemorrhage, the diagnosis is evident and the indications for treatment are both definite and urgent.

Hemorrhage.—Severe hemorrhage must be differentiated from shock, although the differential diagnosis is of little moment, because the treatment of both conditions is identical and because a hemorrhage so often instigates the shock state. In sudden, severe hemorrhage, as when a large artery is severed, the skin becomes cold, clammy and pale, the respirations are gasping and the temperature of the body subnormal. The body tissues suffer from anemia, the patient often complains of a sensation of suffocation (air hunger) and becomes extremely restless. The pulse is very rapid and weak and death quickly ensues. During the hemorrhage the blood-pressure rapidly falls below the so-called "critical level."

Prophylactic Treatment of Shock.—For many years Dr. A. J. Ochsner has insisted that careful attention to details, namely, avoidance of exposure of the body to cold, gentle manipulation of tissues, clean, sharp dissection, nerve-blocking by Crile's method, careful hemostasis, etc., are little things of big moment to the patient. Minor details, such as avoiding useless trauma to tissues occasioned by the prolonged pull of retractors, preliminary elevation of the foot of the operating table to facilitate gravitation of the small bowel upward out of the operative field in pelvic operations, elevation of the head of the table to prolong cerebral anemia and diminish the amount of ether required in thyroidectomies, all of these seemingly insignificant details serve to increase the margin of safety for the patient.

Treatment.—There is abundant evidence to prove conclusively that exposure to cold has a very marked effect on instigating and increasing the state of shock. Accordingly, every effort must be made to restore the body heat to the normal temperature. Avoid exposure of the body. Apply external heat by means of hot-water bottles. Wrap the patient in warm blankets. Administer hot drinks to restore the body fluids and increase the blood volume. Morphin should be given in large enough doses to keep the patient quiet. The systolic blood-pressure readings are usually low. With a systolic pressure below the "critical level," namely, 80 to 90 mm. of mercury, a blood transfusion should be instituted without delay. It is common knowledge that blood transfusion is the specific treatment for shock secondary to hemorrhage and the clinical improvement is both rapid and certain, provided the oxygen deficiency of the tissues has not existed for too long a time. A small percentage of patients will require repeated transfusions if the blood loss has been severe.

Transfusion of blood is indicated in patients who have lost considerable blood during a prolonged or severe operation in whom the blood-pressure tends to remain low in spite of supporting treatment. Cases of secondary anemia, with suppurating wounds and sinuses, often make a rapid convalescence after repeated transfusions. For several years it has been the practice at the Augustana Hospital to group the blood of a large number of available individuals in good health who have a negative Wassermann test and are desirous of giving their blood for a small fee. In this way donors properly grouped are always available for any emergency. The technic employed is the massive transfusion of whole blood by means of Dr. Percy's modification of the Kimpton paraffin tube method. Amounts of blood varying from 500 to 1000 c.c. can be transfused within a period of five to six minutes. This method has been shown to yield a smaller percentage of reactions than the citrate method and possesses the additional advantage that the patient receives the blood without the addition of any chemical agent in as near the normal state as possible. The technical details of this method are discussed by Dr. Percy in another chapter. It should be emphasized at this point, that the splendid clinical results obtained by blood transfusion therapy in thousands of soldiers suffering from shock and hemorrhage, with an enormous saving of lives, has established this method of treatment on a sound and popular basis.

Bayliss[1] has introduced the infusion of a 6 per cent. solution of gum acacia in 0.9 per cent. sodium chloride as a substitute for blood transfusion when blood is not available in sufficient quantities. He advocates infusion of 500 c.c. amounts by the intravenous route within a period of twenty minutes. This solution has the advantage over normal salt and adrenalin infusions, in that it does not leave the bloodvessels rapidly and it restores the blood-pressure by increasing the total blood volume. It has the disadvantage that, unlike blood, the oxygen carriers or red blood cells are not increased by this solution. However, surgeons who have had experience with the gum-salt infusion method report that fatalities were not uncommon some of which must be attributed to the solution. As regards the use of various drugs, namely, strychnin, camphorated oil, etc., little need be said except to point out that their effect at best is very transitory and there is probably very little to commend them.

SURGICAL OPERATIONS IN RELATION TO SHOCK.

Finally, we come to a consideration of the treatment of those cases of shock in whom injuries or disease demand surgical procedures as a life-saving measure. It is well known that operations on patients in the shock state or those who have recently recovered from a severe hemorrhage are attended by grave dangers, due primarily to the low blood-pressure. These cases do not stand ether anesthesia well. Clinical observations have demonstrated that the anesthetic of choice is nitrous oxide and oxygen in the ratio of three parts of nitrous oxide to one part of oxygen. Morphin should be given before operation, and great care is essential that cyanosis and deep anesthesia be absolutely avoided, as they precipitate an additional fall in an already low blood-pressure. Exactly the same precautions relative to the gentle handling of tissues, avoidance of exposure to cold, etc., apply here. If amputation of an extremity is imperative a tourniquet should be applied proximal to the lesion and removed only after the amputation has been completed.

SUMMARY OF METHODS FOR COMBATING SURGICAL SHOCK.

For those patients in the shock state who demand surgical treatment as a life-saving measure the following suggestions are pertinent:

1. The anesthetic of choice is nitrous-oxide-oxygen gas. It should be administered by a skilled anesthetist and great care taken to avoid cyanosis.

2. Avoid unnecessary exposure of the patient's body during operation. All surgical manipulations must be conducted with the greatest degree of gentleness and care must be exercised to avoid those factors which precipitate or aggravate the general shock state, viz., rough

[1] Intravenous Injection in Wound Shock, London, 1918.

handling of tissues, prolonged exposure of the bowel or other viscera, needless handling of the intestines, pulling on the mesentery, etc. It goes without saying that all surgical procedures should be conducted as rapidly as is consistent with good surgery.

3. Transfusion of blood is specific for the treatment of shock secondary to severe hemorrhage. There is also good reason for believing that transfusion of whole blood may act as a prophylactic against the development of shock in patients subjected to prolonged or severe operations. Certain it is that patients respond in a most striking and beneficial manner after a transfusion performed either during or at the completion of such an operation.

4. Postoperative care of the shock patient demands the application of external heat. The body should be wrapped in warm woollen blankets. Hot-water bottles, carefully protected, should be applied to the patient's body. Hot drinks may be given by mouth.

5. The blood-pressure and blood volume must be restored. Saline hypodermoclysis is often a valuable adjunct when transfusion is not possible.

6. The more common drugs employed to combat shock, such as strychnin, camphorated oil, adrenalin solution, etc., all have the practical objection that their action is at best but transitory. Morphin by hypodermic injection is of definite value in many cases. It diminishes the amount of anesthetic required and subdues the useless muscular exertions of the restless patient. It blocks the passage of external pain stimuli to the higher cerebral centers.

INFLAMMATION AND HEALING OF WOUNDS.

By JOHN W. NUZUM, B.S., M.D.

Definition.—Inflammation may be defined as the series of phenomena which follow local injury to the tissues of the body. It is a complex vascular and cellular response on the part of the tissues involved, whereby the blood serum and blood corpuscles are mobilized at the site of injury in order to engage and destroy the invading bacteria, overcome the infection, aid in removing the inflammatory debris and ultimately prepare the field for reparative processes of healing.

Sir John Sanderson defined inflammation as "the succession of changes which occur in a living tissue when it is injured, provided that injury is not of such a degree as at once to destroy its structure and vitality." Professor Adami's definition is as follows: "The series of changes constituting the local manifestation of the attempt at repair of actual or referred injury to a part or briefly the local attempt at repair of actual or referred injury."

Formerly inflammation was considered by pathologists as a destructive and harmful process, but subsequent bacteriological studies have proved conclusively that the tissue response in inflammation is largely of a protective nature and represents the body defences against invasion by various microörganisms. It should be clearly understood that repair goes hand-in-hand with inflammation and constitutes the end-picture of the phenomenon.

Etiology.—The causes are both numerous and varied, and may be subdivided into:

(*a*) *Predisposing causes,* such as general debility, senility, cardiac and renal disease, syphilis, gout, rheumatism, tuberculosis or infectious diseases in general, all tending to lower the normal bodily resistance.

(*b*) *Exciting causes* are injuries and infections. Accordingly the inflammatory irritants may be classified as mechanical, such as wounds or contusions of the body; chemical, such as burns by acids or alkalies; thermal, as exposure to the rays of the sun (dermatitis solare or sunburn); freezing the exposed parts of the body; and specific inflammations of the tissues as, for example, erysipelas which is caused by the presence of the streptococcus in the subcutaneous lymphatics. Some authors believe that all inflammatory processes are the result of microörganisms or the toxins produced by the bacteria which lead to necrosis of the tissue cells of the host. However, it would seem that while bacteria probably are responsible for the greater number of inflammatory processes, such is not always the case.

Pathology of Inflammation.—The pathology of acute inflammation may be conveniently considered under the following heads, viz.: (1) circulatory changes; (2) migration of blood corpuscles and fluids into the tissues; (3) changes in the perivascular tissues. When pathogenic staphylococci gain access to the deeper tissues of the body and are able to multiply in sufficient numbers to set up an acute inflammatory reaction the process may be described as follows:

1. The circulatorychanges consist of a transitory contraction of the bloodvessels of the affected part followed by a dilatation of the vessels with an acceleration of the velocity of the blood stream (active hyperemia). Later the blood stream becomes slower and eventually an actual stagnation of the blood current results in a condition of passive hyperemia. With the slowing of the blood the leukocytes tend to separate from the central or axial stream and come to roll along and accumulate against the walls of the bloodvessels (margination). The leukocytes and platelets tend to associate at the periphery while the red cells gain the axial portion of the blood stream.

2. *Exudation*, or the passage of the constituents of the blood through the vessel walls, begins as soon as a passive hyperemia has been established. The polymorphonuclear leukocytes insinuate their pseudopodia between the endothelial cells lining the vessels and rapidly worm their way through the vessel walls to gain access to the adjacent perivascular tissues in large numbers. The plasma of the blood passes into the surrounding tissues in excess of the amount required to nourish the tissue cells, and since it is not carried away sufficiently rapid by the lymphatics, an inflammatory edema results. The red cells and blood platelets, lacking ameboid movements, are carried through the vessel walls by diapedesis. Finally, there is a marked increase in the total number of the leukocytes, both in the inflammatory zone and also in the general blood stream (leukocytosis).

3. *Changes in the Perivascular Tissues.*—With the myriads of leukocytes mobilized in the zone of inflammation the combat for supremacy ensues between the invading bacteria and the defensive white blood corpuscles. Many of the polymorphonuclear leukocytes exert a phagocytic function engulfing the bacteria and destroying them while others are disintegrated and liberate thrombokinase, which acts on the fluid present in the tissues to form the delicate meshwork. The leukocytes perform additional important service, not alone destroying the invading microörganisms but acting as scavengers they digest the dead tissues and pass back into the circulation through the lymphatics; if suppuration ensues they become pus cells. At the same time the liquor sanguinis present in the tissues at the site of injury possesses both bactericidal and antitoxic properties against the bacterial invaders. Finally, the area is cleaned of debris, the fibroblasts proliferate to form new connective tissue, new capillaries develop to vascularize the newly formed connective tissue and healing may be said to be well advanced. Thus it seems that acute inflammation represents a protective process whereby Nature pours large numbers of

cells and quantities of fluid into the inflammatory zone to meet and destroy invading microörganisms, neutralize bacterial toxins and furnish digestive ferments to liquefy and facilitate disposal of the inflammatory debris.

VARIETIES OF INFLAMMATION.

Varieties of inflammation may be subdivided into *acute* forms, with sudden onset and severe course; *subacute*, with insidious onset and milder type and *chronic inflammation* of low grade and long duration. *Parenchymatous* refers to involvement of the parenchyma or secreting cells of an infected organ as contrasted with *interstitial inflammation* where the connective-tissue cells are affected. *Traumatic*, due to an injury; *specific infective*, due to various microörganisms; *serous*, with profuse serous exudation; *purulent or suppurative*, characterized by excess of pus; *hemorrhagic*, associated with bloody exudate; *catarrhal*, as in inflammation of mucous membranes; *pseudomembranous*, characterized by the presence of a false membrane formed from the tissues rather than from the exudate; *gangrenous*, with necrotic foul-smelling exudation; *metastatic*, as in inflammation at a distant point from the original focus through blood-stream dissemination, etc.

Symptomatology.—The local symptoms are pain (dolor), heat, (calor), redness (rubor), swelling (tumor), and disturbance of function (functio laesa).

Pain of acute inflammation is of slow onset, constantly present in the same location, and is increased by palpation of the affected area or by allowing the part to be placed in a dependent position. This pain is due to the pressure of the inflammatory exudate on the terminal nerve endings and probably also to the tissue changes resulting from the presence of bacterial toxins. Heat is due to the increased amount of blood brought to the affected part. Redness is due to the increased blood content. In acute inflammation the skin may be a livid scarlet red but with older cases it fades into a dusky purple hue. Swelling results from exudation and varies greatly in different parts of the body. Disturbance of function results directly from the pain and swelling of the inflamed parts.

The constitutional symptoms naturally vary greatly with the severity and location of the lesion. In mild cases slight or none are present, while in severe inflammations chills, fever and even prostration are often seen.

Treatment.—Treatment resolves itself into local and constitutional. Local treatment has three main things in view, namely: (1) removal of the cause of the inflammation; (2) rest of the affected part; (3) reduction of the swelling and hyperemia, with relief of pain. Causative bacteria are removed by thorough drainage of suppurating wounds, with deep pockets, and especially is drainage important where the pus is under great pressure. Rest of the affected part is essential as it greatly diminishes the amount of blood to the inflamed area, lessens the pain and decreases both the spread of the inflammation and the danger of general sepsis. In inflammation of the extremities, elevation of the arm or leg after the proper application of a hot boric-acid-alcohol dressing, extending well beyond the area involved proximal as far as the body, not only lessens the swelling and decreases the pain, but tends to hasten convalescence and to prevent widespread dissemination of the invading bacteria in the blood stream.

Hot and cold applications as the patient desires may be valuable in relieving tumefaction and pain in earlier stages of inflammation. Bier's "passive hyperemia" treatment is based on the belief that the increased number of blood corpuscles and the excess of blood serum exert favorable action on inflammatory processes. He advocates obtaining this increased hyperemia either by constriction above the zone of inflammation or by a suction apparatus. Constitutional treatment demands the use of tonics together with proper dietetic management and plenty of sunshine and fresh air in the chronic inflammatory processes, which may prove to be of tuberculous, luetic or rheumatic origin. Finally, I wish to emphasize the splendid results obtained in the treatment of inflammations and infections by the application of the simple therapeutic light as employed at the Augustana Hospital. The rapidity with which inflammatory processes subside and the great comfort and diminished pain afforded the patient convinces one of the practical value of this simple measure.

HEALING OF WOUNDS.

The repair or healing of wounds is a normal physiological process as contrasted with inflammation, which is distinctly a pathological process. Repair goes on hand-in-hand with inflammation. Within twenty-four hours the edges of a wound may be glued together by fibrin and mitotic figures can be demonstrated in the connective tissues. In the repair of tissues the parenchyma cells play but little part, the connective tissues play the chief role. Indeed, it may be stated as a general rule, that the more highly specialized the tissue the less its power of regeneration.

Before repair begins, large amounts of inflammatory debris must be removed. The polynuclears and large mononuclear cells present in the inflammatory exudate act as scavengers, engulfing bacteria, digesting dead tissues and picking up fragments to eventually make their way to the dilated lymphatics. The lymph glands act as mechanical and chemical filters and thus protect the blood stream from noxious material. Gradually the field of inflammation is cleared up and the way paved for healing.

The phenomena of repair may best be studied in the healing of a surgical incision. When an incised wound heals without suppuration the process is called "*primary union*" or *healing* by *first intention.* Within twenty-four hours the wound edges are glued together by fibrin. The leukocytes have largely removed the inflammatory debris. The fixed connective-tissue cells and the endothelial cells proliferate to form the fibroblasts or young connective-tissue cells. From the walls of the capillaries little protoplasmic offshoots or buds develop which unite with similar capillary buds of other vessels to become canalized as new capillaries and thus the organization or vascularization of the newly formed granulation tissue is effected and the wound is well on the way to healing by primary union. Granulation tissue, at first red, later contracts down thereby compressing the newly formed capillaries and becoming hard and pale white. At a later date the epithelium grows from the skin margins to bridge the gap.

Healing by *"second intention,"* or *granulation* is always associated with more or less suppuration and results when the wound becomes infected and there is a loss of considerable tissue through sloughing. The edges of the wound may become separated and the wound defect fills up from the bottom by the formation of friable capillary tufts surrounded by newly formed fibroblasts. As new fibroblasts develop and become vascularized the cavity is finally completely obliterated. The epithelium gradually grows inward by proliferation of the marginal cells and healing by granulation is complete.

SURGICAL FEVER AND INFECTIONS.

By JOHN W. NUZUM, B.S., M.D.

General Nature of Fever.—Fever is a reaction on the part of the body, under control of the nervous system, and specially of the vasomotor mechanism, which has to do with the heat regulation. Any elevation above the normal temperature of the body constitutes fever. The process is usually associated with or accompanies inflammations or infections of the body. It should be emphasized that fever is not a harmful process to be dispelled by antipyretics and the use of cold packs, as was formally believed, but rather represents a reaction on the part of the body, whereby certain substances are formed in the blood stream to neutralize the toxins and destroy the invading bacteria.

Fever is associated with a definite derangement of the heat-regulating mechanism. Oxidation processes are increased and both carbohydrates and fats are burned up to supply heat energy.

Fever as an Immunity Reaction.—There is real experimental and clinical evidence to prove that fever is a defensive and protective process rather than a harmful one. It has been shown that animals placed in thermostats at elevated temperatures developed specific antibodies in the blood stream, which enabled them to neutralize and destroy lethal doses of bacteria. Moreover, a definite and marked increase in the agglutinins and bacteriolytic substances occurs in the blood of these animals as compared with the controls.

The clinical evidence of the protective value of febrile reactions is well demonstrated in the striking results that follow intravenous injections of foreign proteins in acute painful arthritis. Patients with painful, swollen joints often experience a most rapid disappearance of pain after a severe febrile reaction which follows the injection. Careful investigations of this phenomenon have shown that in general the best results occur in those cases which suffer a severe reaction, viz., a severe chill followed by a temperature of 102° to even 105° C.

The foreign protein calls forth a leukocytosis and both specific and non-specific antibodies are increased in the blood stream.

On the other hand it is well-known that in certain disease processes, such as pneumonia in alcoholics, or the aged, general peritonitis, etc., when the patient runs a subnormal temperature with a low white count or perhaps a leukopenia, the outcome is frequently associated with a grave prognosis. Here again it would seem that fever may be an index of the body resistance to infection.

ASEPTIC TRAUMATIC FEVER.

Aside from elevation of temperature associated with infections the surgeon meets with a type of fever known as traumatic fever or "postoperation rise." This fever occurs after aseptic operations, sprains, fractures, wounds and contusions, and is characterized by the absence of microörganisms at the site of injury or in the operative wound. This mild type of fever commonly appears the evening of the day of operation and persists for twenty-four to forty-eight hours, reaching a maximum of 100° to 102°. It is not accompanied by a chill, and aside from the slight elevation of temperature the patient feels well. The blood often shows a moderate leukocytosis. The wound looks entirely normal and is not painful, red or swollen. The fever is presumably due to the absorption of the products of cellular disintegration, fibrin ferment, serous exudate and extravasated tissue juices. If of mild duration, it has no prognostic significance and requires no special treatment. However, a fever appearing three or four days after operation and persisting practically always means infection and demands immediate inspection of the operative incision, A painful wound with red swollen margins is usually grossly infected. The tension sutures must be loosened, and where pus is present in the subcutaneous tissues the wound should be laid wide open and hot dressings applied to prevent burrowing or deep dissemination of the infection. At a later time secondary suture may be necessary.

MALIGNANT SEPTIC INFECTIONS.

Introduction.—A consideration of surgical infections necessarily calls for a discussion of septicemia and pyemia. Infection may be defined as the condition produced by the entrance and multiplication of pathogenic microörganisms within the body. In local infection the growth of the bacteria is largely restricted to the portal of entry and the associated tissue changes result from the toxic substance elaborated by the bacteria. When these toxic substances pass into the general circulation, giving rise to mild or grave constitutional symptoms, the condition is known as toxemia. Diphtheria furnishes an excellent example of a toxemia, since the growth of the bacilli is largely restrained to the exudate over the tonsils and soft palate while the complicating paralysis of the muscles of the soft palate is due to the effect of the toxins on the nerve supply to these tissues. Sapremia is an obsolete and vague term applied to those conditions in which the symptoms are due to the absorption of poisonous products of decomposition without the presence of microörganisms in the general blood stream. Sapremia is well illustrated by the symptoms arising during the puerperium from portions of placental tissue retained within the uterus and undergoing decomposition.

When during the course of infection pathogenic microörganisms gain entrance through the lymphatics into the blood stream and multiply in the blood and tissues of the body the process is known as septicemia. Formerly, septicemia was considered as a surgical affection limited largely to the pyogenic bacteria, namely, the Streptococcus and Staphylococcus pyogenes aureus. More recent investigations have shown conclusively that many of the acute infectious diseases, such as pneumonia, typhoid fever, epidemic cerebrospinal meningitis, rheumatic fever, etc., are all accompanied by an early general invasion of the blood stream by the causative bacteria, with later specific localization in the various tissues. Blood cultures taken early during the febrile period of the disease or at the time of a chill will often yield pure cultures of the causative microörganism, although the percentage of positive cultures is largely dependent on the cultural media employed and the technic and experience of the bacteriologist. To this general blood-stream invasion the broader and more comprehensive term bacteremia has been applied.

If during the course of a septicemia or bacteremia, the invading microörganisms give rise to the formation of multiple metastatic suppurative foci or abscesses in various organs of the body the condition is known as pyemia. It will thus be seen that these different infectious processes are closely linked together and may be said to represent various degrees of severity of infection, depending largely on the general defensive powers of the human body. Pyemia presupposes the existence of a septicemia or bacteremia and represents merely the end-picture of the disease.

Etiology.—The etiology of septicemia and pyemia will be considered together. Our information is entirely due to the careful, painstaking, bacteriological examinations of the blood during life, together with routine cultural examinations of the body tissues and fluids at necropsy. It is obvious that septicemia can result only from infection somewhere within the body, but the portal of entry of the bacteria is frequently difficult to determine. It may result from an attack of tonsillitis, from infected teeth, otitis media, sinusitis, prostatitis, chronic appendicitis, gall-bladder disease, pelvic infections or gastric ulcer. The septicemia often results from a trivial scratch which has been forgotten or from a superficial pin-prick of the finger. Finally a most careful search may fail to reveal the portal of entry of the infection and to this class the name cryptogenic septicemia is given. It should not be forgotten that the bacteremia following pneumonia is frequently due to the causative microörganisms, the pneumococcus, while in scarlet fever a septicemia often is due to the common secondary invader, the streptococcus.

The organisms isolated from septicemias in relative order of importance and frequency are as follows: the Streptococcus, Staphylococcus pyogenes aureus, Pneumococcus, Bacillus typhosus, Colon bacillus, Bacillus pyocyaneus, Bacillus mucosus capsulatus, Meningococcus and some few others.

Terminal Infections.—Patients suffering from chronic diseases of the heart, kidneys, liver and lungs frequently succumb as a result of secondary or terminal infections. Osler is authority for the statement that "the majority of cases of advanced arteriosclerosis and of Bright's disease succumb to these intercurrent infections."

Flexner in a large series of 793 autopsies found 255 cases of chronic heart and kidney disease, in 213 either a local or general infection was present and in 52 there was a general infection of the body. He found the following organisms in order of frequency: Streptococcus pyogenes, Micrococcus lanceolatus, Staphylococcus pyogenes aureus, Bacillus welchii, Bacillus coli, Micrococcus gonorrhœæ, Bacillus anthracis and Bacillus proteus.

Technic and Value of Blood Cultures.—It is obvious that bacteriological examinations of the blood during life yields information of great scientific, diagnostic, therapeutic and prognostic value. Moreover, the rational employment of both sera and vaccines absolutely demands an accurate knowledge of the pathogenic microörganisms responsible for the disease. The persistence of large numbers of colonies of pneumococci in the blood stream during pneumonia gives a distinctly bad prognosis. The differential diagnosis between miliary tuberculosis and typhoid fever is immediately established by positive cultures of Bacillus typhosus when the clinical symptoms and physical findings are indefinite. It must be remembered that in septicopyemia, osteomyelitis or suppuration, bacteria may only be present in the blood at intervals, and especially is this liable to be true during the chill.

The method of obtaining cultures from the blood may be briefly outlined as follows: The skin is carefully cleansed with alcohol or ether and may be painted with iodin. A constrictor is placed on the arm and the blood is withdrawn by venipuncture into a sterile glass syringe attached to a sharp needle. The median basilic or cephalic vein at the elbow is conveniently selected. Before clotting the fluid blood is inoculated in small amounts, viz., 5 c.c. blood into 50 or 100 c.c. flasks of dextrose ascitic broth. Great care must be exercised to avoid aërial contamination. By using small amounts of blood the natural bactericidal properties of the blood may be largely overcome. Anaërobic cultures and inoculations of blood-agar plates should also be made. Staphylococci are frequently contaminations from the skin puncture. The inoculated cultural media is placed in the thermostat at 35° C., and allowed to incubate for twelve days. Daily examinations are made for evidence of bacterial growth, viz., turbidity and the organism is identified by morphological study of stained smears, cultural reactions and serological determinations. Certain of the less common pathogenic bacteria require special media for isolation.

Morbid Anatomy.—The bodies of patients dead from septicemia present little or no postmortem rigidity. Decomposition begins very early after death. The blood shows little tendency to clot and postmortem hemolytic staining of the lining of the aorta and of the serous surfaces of the pleura and endocardium are often marked. Disseminated petechial hemorrhages are present beneath the skin, and especially in the pleura, pericardium and epicardium. Occasionally these minute hemorrhages predominate throughout the body in so-called cases of hemorrhagic septicemia. The spleen is generally enlarged. The capsule may be soft and wrinkled and the splenic pulp is frequently soft and mushy. The heart, liver and kidneys present the common picture of cloudy swelling and fatty changes. An old otitis media, prostatic abscess or diseased appendix at autopsy may represent the hidden portal of entry of the infection.

Pathology of Pyemia.—In discussing the pathology of pyemia we must assume the presence of pyogenic organisms in the blood stream, but the essential characteristic is the development of multiple suppurative foci in various organs and tissues of the body. In the majority of local suppurative processes leading to pyemia the walls of the veins adjacent to the area undergo an inflammatory process leading to the production of a thrombophlebitis. Small portions of these infected thrombi are swept into the blood stream and lodge usually in the lungs in the small capillaries or terminal vessels. Since these are infected emboli they produce widely disseminated minute metastatic abscesses, with a central zone of clumped microörganisms surrounded by a small area of necrosis and beyond this an area of leukocytic infiltration encapsulated by newly formed connective tissue. It has been demonstrated experimentally that anything which causes clumping or agglutination of the bacteria favors the development of abscess formation in the tissues. Moreover, bacteria in the blood stream show a special tendency to localize at the site of injured tissues. Indeed, it has been found possible to produce osteomyelitis in animals by fracturing a bone and then introducing microörganisms intravenously as they tend to be arrested at the site of the fracture and set up an acute suppurative process. In a similar manner appendicitis can be produced by crushing or ligaturing the appendix prior to intravenous inoculation. Endocarditis in animals is readily induced by intravenous injection of pyogenic bacteria, provided that the valve is the site of a previous mechanical injury. There can be no doubt that this factor of lowered resistance or tissue injury (locus minoris resistentiæ) is a very important element in the production of pyemia as well as in the causation of other acute disease processes.

Thrombophlebitis in the neighborhood of pulmonary abscesses may give rise to showers of minute metastatic abscesses in the kidneys, spleen, myocardium, brain or muscles.

An unusual form of pyemia is that resulting from infections of the gall-bladder, stomach, bowel or most frequently in the appendix leading to the production of a septic thrombosis of the portal vein, with multiple abscesses of the liver, a condition always fatal and known as suppurative pylephlebitis.

Symptomatology.—Septicemia frequently complicates the puerperium, due to errors in technic at the time of labor, *i. e.*, the so-called puerperal sepsis. A common and severe type of septicemia follows infections in the postmortem room. A slight abrasion of the finger or hand within a few hours may present the red streaks of lymphangitis running up the patient's arm. The epitrochlear and axillary glands become swollen and painful. There are frequent chilly sensations or actual rigors followed by fever, usually moderate, but often high. The patient is prostrated and takes to bed. The fever often shows morning remissions and evening exacerbations. As the case progresses the temperature may fluctuate greatly. The pulse is rapid and weak. The tongue is dry and furred. The urine is scanty in amount and of high color. Sweating may be profuse. Vomiting and diarrhea are often prominent symptoms. Prostration dominates the general picture. The spleen may be palpable. There is a progressive and severe secondary anemia. Leukocytosis is usually marked except in those cases which succumb before the body has an opportunity to react. Repeated blood cultures taken during a chill will often yield pure cultures of the microörganisms responsible for the condition. A negative culture has no value while a positive result often gives information of prognostic and therapeutic value. Toward the end the patient may present the so-called facies Hippocratica, *i. e.*, pinched nose, hollow temples, sunken eyes, etc. Low muttering delirium gradually is replaced by stupor and death. In the more protracted cases bronchopneumonia, lung abscesses, endocarditis, meningitis, peritonitis, arthritis or even osteomyelitis may appear as complicating sequelæ.

The symptoms of pyemia are quite similar to septicemia. The disease is ushered in by a severe chill or a series of chills. The temperature rises rapidly and fluctuates widely. With each successive shower of septic emboli there occurs a severe chill followed by drenching sweats. The temperature is subject to the greatest variations and may even drop to normal, only to shoot up again when new foci of suppuration develop in distant organs. The general symptoms of great prostration and weakness, vomiting, petechial hemorrhages in the skin, etc., are similar to those of septicemia. Acute pyemia may end fatally within a week while chronic cases may drag along for several months. The complications have been considered above.

Diagnosis.—A patient presenting in general the symptoms tabulated in the above paragraphs in association with a suppurating wound, an old osteomyelitis, chronic otitis media or a compound infected fracture must at once suggest the possibility of a septicemia or pyemia. When the symptoms develop rapidly after childbirth or subsequent to an autopsy infection the diagnosis is easy. Positive blood cultures render the diagnosis absolutely certain.

It is extremely important to determine the portal of entry, as many chronic septicemias due to absorption of the microörganisms from infected tonsils, carious teeth, sinus disease, chronic appendicitis or gall-bladder infection clear up quickly after appropriate surgical treatment. In those forms of septicemia and pyemia due to hidden foci of infection such as prostatic abscesses, posterior urethritis or intestinal tract disease, the diagnosis is often difficult and is frequently misinterpreted as malaria, typhoid fever or miliary tuberculosis. Pyemia is to be suggested from the character of the fever and the localizing symptoms of complicating abscesses when present in the lungs, kidneys, etc.

Prognosis.—The prognosis naturally varies with the age of the patient, duration of the disease, type of infecting microörganisms and the defensive power of the body. In general it may be stated that streptococcal septicemia offers the worst prognosis. In surgical septicemia, puerperal sepsis, etc., complicated by meningitis, peritonitis or endocarditis, the death-rate is very high. Suppurative pylephlebitis is always fatal. In the chronic types of pyemia with mild joint involvement recovery often follows.

Treatment.—The treatment naturally falls into three general divisions, viz., local, general and specific.

Local Treatment.—Local treatment demands the eradication of all foci of suppuration. Abscesses must be drained, carious teeth extracted, middle-ear disease treated—in fact a most thorough search should be instituted for hidden foci of infection which may be feeding bacteria into the general blood stream. The tonsils, prostate and genito-urinary tract must not be overlooked.

General Treatment.—Absolute rest in bed is imperative. Fresh air can only do good. A liquid diet of high caloric value and given at frequent intervals is essential. Rectal feedings may be necessary. Copious consumption of large quantities of water is always beneficial, as it promotes elimination through the kidneys, bowels and skin. Hydrotherapy may be employed. Saline hypodermoclysis is often of value. Digitalis should be administered for a weak heart. Repeated blood transfusions are of benefit in those chronic cases with marked secondary anemia and low bactericidal properties in their blood.

Specific Treatment.—This method of therapy demands a careful bacteriological study of the patient's blood. If the septicemia is due to the streptococcus, large doses of antistreptococcal serum (polyvalent) may be given intravenously, and as early in the course of the disease as possible. Investigations have shown that the streptococci fall into several distinct classes. Each type possesses different cultural and serological characteristics and the questionable results of streptococcal serum therapy may be due to previous inadequate dosage or actual impotency of the serum. The serum when properly given is harmless, and in addition to its high opsonin content it stimulates the production of both specific and non-specific antibodies in the blood stream of the patient.

In general it may be said that our knowledge of the streptococci as a group is as yet very incomplete and the disappointing results of streptococcal serum therapy in the past may be directly attributed to this fact. Recent epidemics of a peculiar, highly fatal type of bronchopneumonia developing among soldiers convalescing from measles has been definitely shown to be due to the hemolytic streptococci. The antigenic properties of these hemolytic streptococci and the therapeutic value of specific serum therapy are problems for future bacteriological study to solve.

POSTOPERATIVE TREATMENT.

By JOHN H. GIBBON, M.D.

In no department of surgery will be found the exhibition of so great a display of individuality as in the after-treatment. Many surgeons are inclined to attribute their good results to their peculiar plan of postoperative care and yet, others, carrying out a postoperative treatment which is the exact opposite, claim equally good results. In recent years, however, there has been more unanimity of opinion, less stoutness in adhering to fixed rules, and more consideration shown to the individual patient. The change which has come about has been distinctly toward simplicity and a postoperative treatment directed especially toward the patient's comfort. These changes speak for reason and common sense. It is foolish to attempt to lay down for instance an iron-clad rule that every patient must have a bowel movement on a certain day following operation and equally absurd to say that every patient, after an operation, must have water withheld from the stomach for a definite number of hours. Common sense must guide us to a large extent, for in one case it may be imperative to have the bowels open the day after operation and in another no necessity for a movement for several days; one patient may be able to take water within a few hours after operation without nausea or ill effect where another may have his postoperative discomfort and nausea greatly increased. It should be understood therefore that what follows must not be taken as an inflexible guide never to be departed from unless it is so stated.

Paradoxical as it may sound, postoperative treatment really begins before the operation in the preparation of the patient for the operation and extends throughout the operation itself because prevention is the most important part of treatment and much can be done before and during the operation to accomplish it. No discussion of postoperative treatment would be complete without mention of some of the factors which produce postoperative discomfort and complications and these should receive the first consideration.

Correct Diagnosis.—It may not be amiss in considering the postoperative comfort and safety of the patients to say that a correct diagnosis before the operation adds greatly to both. The failure to study carefully our patients, or to call to our aid the various laboratory methods of diagnosis, the tendency to look upon conditions as emergencies which are not emergencies at all and to do exploratory operations upon patients where an approximate diagnosis can, with a little care and effort, be made beforehand, result too often in a multiplication of incisions, a repetition of the operation and occasionally in the unnecessary death of the patient. Haste to operate in a case of appendicitis complicated by some acute infection of the respiratory mucous membrane, "just an ordinary cold," is sure to result in a serious lung infection after the operation and serves to illustrate one of the points I would make. Hasty operations done for supposed acute abdominal crises, when the real condition is a pneumonia or a pleurisy, is another illustration. And still others are the hurried operations which have been done in cases of typhoid fever under the impression that the patients were suffering from appendicitis and where a simple leukocyte-count would have resulted in the avoidance of these catastrophes.

It is these mistakes which we have made in the past that cause me to suggest that a correct diagnosis before operation has a remarkable bearing on the result and that hasty operations and those not preceded by a careful study of the patient and the employment of all those measures which aid diagnosis and tend to indicate the risk of operation and the patient's ability to withstand them, not only bring discomfort, danger, and often disaster to the patient, but are a distinct discredit to the surgeon and to surgery.

Choice of Anesthetic.—Probably in certain cases nothing contributes more to the patient's postoperative safety than a proper choice of anesthetic. Every experienced surgeon has a very marked preference for a certain anesthetic and is prepared to defend it on all occasions, and it is not my idea to attempt to change the opinion of any one in regard to his favorite anesthetic agent, but rather to urge that no one agent is always the best. There is no "safest anesthetic" for all cases. Ether, generally speaking, is probably the least dangerous of anesthetics, but its irritating properties contra-indicate its use in the presence of acute infections of the respiratory tract, where nitrous oxide, chloride of ethyl, regional anesthesia or infiltration anesthesia can be used with comparative safety. In nephritis too, ether, instead of being a safe anesthetic, becomes a dangerous one. In disease of the heart valves and muscle, nitrous oxid, chloride of ethyl and chloroform are far more dangerous than ether. The use of some one of the various forms of regional or local anesthesia often places a particular operation in the category of safety, whereas a general anesthetic might make it unjustifiable. The use of intratracheal anesthesia and of spinal anesthesia in certain operations is plainly indicated and much safer than the ordinary means of bringing about the anesthetic state. What we need is a broader experience in the use of all anesthetics and the ability to exercise a wise choice in the selection of the particular anesthetic or method of administration in the individual case. There can be no doubt that such broader experience and choice of anesthetic will influence favorably the early recovery and convalescence of our patients. I cannot leave this subject without stating as a firm conviction that the administration of morphin and atropin by hypodermic one-half hour before the operation, not only results in a better and more complete anesthesia, but that it also helps to reduce the amount of the anesthetic to be used during the operation, tends to prevent shock and adds enormously to the patient's comfort and safety during the few hours immediately following the operation.

Alimentary Tract.—The former method of administering a purgative the night before operation has been given up by most surgeons and wisely because, in abdominal operations especially, the patients suffer in the postoperative period from gas and harmful peristalsis; moreover, the sleep and rest which they should have on the night preceding operation is disturbed. It is far better to give the laxative two, or even three, nights before the operation. Neither the same laxative nor the same dose should be given to every patient but the individual intestinal habit taken into consideration. Many a patient has been made uncomfortable and the intestinal tract greatly irritated by too free purgation or by the excessive or improper use of enemata just before being subjected to a surgical operation. My own custom is to find out what laxative the patient has been in the habit of taking and how it acts and then to give him, two nights before his operation, a sufficient dose of this laxative to produce two or three good bowel movements. After most operations the patient needs plenty of liquid and it is a mistake to deplete a patient before operation by producing a number of watery bowel movements.

Too much attention, as a rule, is given to the bowels and too little to the condition of the mouth and nasopharynx. Even a slight acute inflammation of the upper respiratory tract is too often the cause of postoperative bronchitis or pneumonia. A cold in the head should be looked upon as an absolute contra-indication to the administration of any general anesthetic excepting in cases of the greatest urgency. The failure to properly cleanse the teeth and mouth before operation is a mistake in any operation which involves the mouth, pharynx, esophagus and upper gastro-intestinal tract, as wound infection can often be traced to a foul condition of the mouth.

Nourishment.—After the administering of the laxative, simple easily digested food with plenty of water should be given. Water alone can be given up to within two or three hours of the operation. The free administration of water supplies an element which is badly needed after the operation and tends to prevent the distressing thirst which follows the administration of an anesthetic and the loss of even a moderate amount of blood.

Field of Operation.—Most surgeons have discontinued the use of moist antiseptic dressings over the field of operation. This method certainly renders the patient uncomfortable and disturbs the rest which he should have prior to the operation. Antiseptics applied in this way also tend to produce irritation of the skin which adds to the patient's postoperative pain and discomfort. Iodin, if improperly employed, especially upon delicate skin, may cause blistering and even wound infection. In order to prevent these complications, the iodin should be largely removed from the skin with alcohol at the conclusion of the operation. Too vigorous use of strong antiseptics on the skin cannot be too forcibly condemned.

The Urinary Tract.—Much of the postoperative trouble and discomfort arising from retention of urine can be avoided by a little investigation and care before the operation. The time to discover that a patient has a stricture, an obstructing hypertrophy of the prostate, or a specific urethritis is before and not after the operation. If such conditions are relieved before the patient is subjected to operation, a much smoother convalescence can be expected. While believing that the routine use of the catheter immediately before operation both unnecessary and foolish, I think that when the patient can, he should void urine just before the operation and, if he is unable to do so, the bladder should be emptied by catheter at the conclusion of the operation. If this precaution is taken, it prevents the patient's bladder from becoming distended within the first eight or ten hours after operation. It also enables us to estimate the amount of urine secreted during the first forty-eight hours after operation with some degree of accuracy.

Patient's Clothing and Position on Operating Table.—There can be no question that insufficient clothing and exposure of the patient before and during the operation contribute not only to postoperative discomfort but increase shock, lower resistance, and consequently render postoperative complications more likely. The too prevalent habit of removing warm woolen underclothes, in which the patient may have been in the habit of sleeping, and dressing him in a thin cotton shirt open down the back, is wrong and where it is followed we should not be surprised to find our patients on the day of operation with acute colds in the head. Exposure on the operating table and extensive and careless use of solutions over the patient's body should also be avoided. These solutions may be warm when they are applied but they soon cool and the patient lies covered with cold wet garments. It is too often the custom in abdominal operations to keep only the legs of the patient wrapped in a blanket, allowing the chest to be absolutely exposed to air and fluids which too soon become cool. A light blanket or woolen shirt should always encase the chest. The blanket which is over the lower extremities should come up as high as possible without interfering with the field of operation. In other words, only so much of the patient should be exposed on the operating table as is positively necessary. Various methods of keeping the patient warm on the operating table have been devised, such as a rubber mattress containing hot water or an electrically heated table. Personally, I believe that if the patient is properly prepared beforehand, and if the surgeon and his assistants are careful not to allow the clothing to become saturated with fluids, there will be no necessity for any of these specially devised tables. If, on the contrary, it is the surgeon's custom to use large quantities of fluids, then some such method of heating the table is valuable.

An unnatural position on the table with stretching of muscles and joints or with pressure on superficial nerve trunks may be the cause of a great deal of postoperative suffering. Some of the unnatural positions into which the body is placed are necessary but they should not be maintained longer than absolutely needed. Much of the backache which the patient complains of after operation is due to the position occupied on the hard operating table. The perfectly flat position is very trying, especially to very stout patients, and it will be found that a slight elevation of the head and shoulders and a moderate flexion at the knees will render the respiratory act much easier and the postoperative backache less. The patient's arms should never be allowed to hang over the edge of the table as such a position is liable to result in a musculospiral palsy which will far outlast the normal postoperative convalescence. A further care should be taken to avoid blistering of the patient's skin by such agents as benzine, ether, etc. If these agents are applied in excess, they collect under the patient and, if the pad on the operating table is covered with rubber, as it usually is, quite severe blistering may occur.

Conduct of the Operation.—Undue haste in the performance of an operation is as bad as unnecessary prolongation of it, the one may lead to injury of organs requiring additional operative procedures or to some catastrophe during convalescence, and the other has to be avoided as it means the use of much more of the anesthetic with the greater likelihood of the postoperative complications which result from anesthetics.

Rough handling of tissues during the performance of an operation results in the injury of organs, reduces their resistance to infection, causes hemorrhage, increases shock, and interferes with healing. I have often thought that we would be better surgeons, would possess more manual dexterity and skill and show greater respect for the tissues we handle if we had to do all our early work with the aid of local anesthesia only.

If a certain care is used in the application of ligatures, much postoperative discomfort and in abdominal work occasionally a serious postoperative complication may be obviated. The ligation of large masses of tissue should be avoided. I believe also that as a rule it is better to use small gut in ligating small vessels. Suture ligatures are much less apt to become displaced than the ordinary ligature. The two great objections to the ligation of large amounts of tissue in the abdomen are that such ligatures are very apt to slip during the subsequent manipulation of the tissues or after the operation and that it is more difficult to cover the raw area to which the intestine is apt to become adherent with a resulting obstruction. When large masses of tissue are included in ligatures passed on the pedicle needle, there is also a risk of including within the ligature some important structure, such as the ureter. The ligation of the individual vessels in the broad ligaments, in the mesocolon and elsewhere is a far better plan than the older method of including a large amount of these structures in a single ligature and is followed by much less likelihood of subsequent adhesion and obstruction. Too much stress cannot be put on the importance of avoiding the ligation of large masses of omentum, as such are sure to become adherent to the intestine or to the abdominal wall, whereas, if a number of ligatures are placed the omentum can be restored to the abdomen and spread out in a fashion somewhat like the normal.

A common fault in technic is the too tight constriction of tissues with sutures. This not only applies to the skin, but to deeper structures. It should be borne in mind that all that is required is a comfortable approximation. Sutures too tightly placed interfere with circulation, produce necrosis, and lower resistance to infection. If the suture material is silk or linen thread, the too tight constriction of the tissues results in cutting and the primary object of the suture is thwarted. Many accidental wounds, such as lacerations of the scalp, are made to suppurate by the too close and the too tight introduction of sutures. In the accident wards of our hospitals it would be much better to provide the interne with horse hair alone as a skin suture, as it is so delicate that too tight tying is impossible.

The care and position of the drainage which may be necessary in an operation has an important postoperative bearing, especially in abdominal work. Personally I am inclined to believe that it is only in exceptional cases that rigid, inflexible drainage tubes should be used, since by pressure they may cause ulceration, especially when introduced into a mucous-lined cavity and often are responsible for persistent reflex vomiting. Such tubes also may be the cause of intestinal obstruction. Whenever a drainage tube is introduced into a mucous-lined cavity, care should be taken to see that the end of the tube does not make pressure on the wall of the cavity; to drain such organs as the gall-bladder it is only necessary to have the tube extend into the cavity for a short distance. Tubes should always be fixed by suture or some other means so that they cannot slip either in or out. This applies not alone to abdominal drains, but to all, and particularly to those of the chest wall. Uncovered gauze drains possess very serious disadvantages, the greatest of which is the disposition of the tissue to become firmly attached to them, thus interfering with drainage to some extent and rendering their removal difficult and very painful. Unless there is sufficient discharge from the wound to keep the drain moist, it is sure to become adherent at its exit from the wound and acts then more as a plug than a drain. Large unprotected gauze drains in the abdominal cavity also produce adhesions which often result in subsequent obstruction. Because of the capillary quality of the gauze drain when placed against a closed organ, such as the intestine, common duct, renal pelvis, ureter, etc., it invites leakage. When covered with gutta-percha or thin rubber dam in such a way as to leave the gauze exposed only at the extremity of the drain or through small openings on the side, the drain at once possesses all the advantages of the tube and gauze drains and many of their disadvantages are obviated. It is true that these drains tend to slip about and may not remain in just the situation that the surgeon would like and therefore they should always be fixed with a light catgut suture in the desired position. As a general rule it is well to let the drain, of whatever character employed, pass out through that part of the wound where it naturally falls instead of carrying it to one or the other extremity of the wound; this is particularly important where it is known that the re-introduction of a drain will be necessary later.

All drains should be fixed at their exit through the skin by a suture, safety-pin or some other device which will prevent any shifting of the drain.

Dressings.—In regard to the material used in dressing wounds and the method of holding them in position, there will probably never be any fixed rule, but it is not out of place in this connection to speak in a general way of both.

In all clean wounds the dressing should be dry and gauze is the material commonly used. Zinc oxide adhesive strips are generally employed for the fixation of the dressing, but care should be taken not to apply these strips to skin covered by hair or to skin recently painted with iodin, unless the iodin has been thoroughly removed with alcohol, neither should the strips be applied so tightly as to interfere with normal movement of the underlying muscles, unless such interference is desired. The adhesive strips should not, as a rule, overlap one another but an area of uncovered skin should be left between them. Wrinkling or pinching of the skin should also be avoided. We often make the mistake in applying the dressings after an operation of placing the parts in abnormal positions, which is only occasionally necessary and which results in a great deal of postoperative discomfort. The old method of fixing the arm to the chest wall after a breast amputation with a tight binder or bandage is as good an illustration as I could give of the point I would make, since the position is unnecessary and gives rise to the greatest pain and discomfort, especially at the elbow. Very often in the use of splints and casts the bony prominences and nerves are not sufficiently protected from pressure and the patient consequently suffers an unnecessary amount of pain and he may suffer for weeks after the healing of the wound or injury from pressure ulcerations or from palsies; it is only necessary to refer to pressure ulcerations over the internal condyle of the humerus, over the heel and to Volkman's contracture and to paralysis of the perineal nerve due to pressure below the knee. We have often seen patients spend days and nights with pain and discomfort due to a too tightly applied spica of the hip. This bandage is frequently applied improperly by an orderly while the patient is still anesthetized and, the only position which will relieve the tension, that of flexing the thighs on the abdomen, is denied the patient by a too careful nurse. A complaint on the part of a patient on recovery from an anesthetic of pain, especially at a distance from the wound, and of tightness or constriction of the bandage, or of a burning tingling pain at the site of a bony prominence requires inspection of the dressing and often the entire removal and re-application of the bandage, the splint, or the cast.

IMMEDIATE CARE AFTER OPERATION.

As far as possible the postoperative care should consist largely in making the patient comfortable and seeing that he does nothing which will disturb the normal healing of his wound and in aiding where necessary the reëstablishment of normal functions.

Immediately after operation, that is from the time the patient leaves the operating table until he has entirely regained consciousness, he should be constantly watched by a nurse or physician who is capable of preventing or dealing with any of the simpler difficulties which may arise in a patient recovering from an anesthetic and of recognizing early the symptoms of hemorrhage, suffocation or collapse. Even after the simplest operation a competent surgical assistant or the surgeon himself should be within easy call in case of emergency.

Restraint and Position.—The patient should be allowed such freedom of movement or position as will not disturb the wound or dressing. Too often patients are restrained from the simplest movement and made to lie absolutely quiet on the back when such restraint is not in the least necessary and only adds to their discomfort and makes them either rebellious or needlessly apprehensive. One often sees a patient who habitually sleeps with two or three pillows made absolutely miserable by being compelled to lie flat on his back with no pillow at all. In the early days of abdominal surgery this restraint was rigidly carried out, the patient not even being allowed to move a leg and the after-treatment was a torture. It is often better to allow the patient to try an attitude, which you know will be painful or uncomfortable and let him discover for himself that it is not advisable, for in this way he is resigned to the necessary limitation of movement. In many cases a change of position such as the legs flexed on a pillow, slight elevation or lowering of the head, a hand on top of, instead of under, the bed clothes, or turning on the side produces a degree of comfort and satisfaction which only morphin can produce. Whenever a patient wishes to assume his accustomed attitude of rest in bed, he should be allowed to do so unless the character of the wound or operation forbids it.

Patients are always restless after an anesthetic unless morphin has been given and at times may be difficult to control. Forcible restraint of a patient, is a mistake as a rule and should be avoided if possible. Often a patient will quiet down if his attention can be diverted and he realizes his surroundings. As soon as a patient recovers from an anesthetic he should be assured that everything is all right and that he is in good condition. Such assurances will usually satisfy him and if it is not given in response to his inquiries, his anxiety is naturally increased. An intelligent and sympathetic nurse at this time is far more valuable than the patient's friends and relatives who are too apt to misinterpret his restlessness and reveal to the patient himself their own anxiety.

The Fowler position is so generally understood at the present that no description of it or illustration seems necessary. It should be understood, however, that this position cannot be comfortably maintained without one of the variously constructed supports which are placed either under or on top of the mattress. A few surgeons of wide experience do not look with favor on this posture, but it is used in cases of peritonitis in a large majority of clinics.

Artificial Heat.—Artificial heat in the form of hot-water bags and hot-water tins can I think be overdone and of course if not properly employed can give rise to the most distressing burns. What a patient requires after an anesthetic of any length is warmth and protection from draughts while perspiration is active. Too much heat either in the shape of hot-water bags or blankets, I am convinced frequently is the cause of continued sweating. As far as possible the skin of the patient should be kept dry and warm. A cold clammy skin, especially when accompanied by restlessness, anxiety, and a rapid small pulse, is of course significant of hemorrhage and presents a very different picture from that of the ether delirium and profuse sweat seen immediately after an operation.

Nausea and Vomiting.—Nausea and vomiting is a more or less constant sequel of operation, especially of abdominal operations. We are prone to boast that with our individual method of inducing anesthesia and of conducting our operations that the patient has "practically no nausea," but this is an indefinite and often untrue statement. Although the anesthesia is responsible to a large extent for the nausea, it is not altogether so for we sometimes see distressing nausea after an abdominal operation performed under infiltration anesthesia. Internes and internist are far too prone to give drugs or drinks for the purpose of arresting nausea and vomiting and the patient and his friends beg for something to "settle the stomach;" drugs in this early stage are much more apt to aggravate it. A far better plan is to give nothing or else a full glass of water, which is usually promptly vomited with some relief.

Care should be taken, especially after those emergency operations where there has been no opportunity to prepare the patient for an anesthetic, to see that none of the vomited material obstructs the pharynx or is inspired. My experience in using morphin and atropin in abdominal cases has shown vomiting to be so much less than in other operations in which it was not employed that I now use it in every operation of magnitude or long duration or those which I expect to be followed by much pain. It is seldom necessary to give a second dose, and this I try particularly to avoid, for it is better not to let the patient learn the comfort of morphin. Repeated small doses after operation do not appeal to me, because the patient is apt to become dependent upon it. When the single full dose is given before the anesthetic, the patient will often sleep for from one to three hours and remain quiet for a much longer period.

Pain developing some hours after an operation is not to be treated by the immediate administration of an anodyne, but its cause should be carefully sought and removed. A careful and considerate nurse can do much to relieve such pain. Oftentimes the simple change of posture, the cutting of a tight bandage, the relief of pressure on some bony prominence, straightening out the clothing, or some such little attention will give relief. I have seen a patient kept awake all night by pressure on the heel after a fracture of the leg, and by pressure on the internal condyle by an internal angular splint. Pain under such circumstances is absolutely unnecessary, and its possible cause should always be considered. I have known a safety-pin to be passed through the patient's skin in fixing a bandage and to remain in this position for days. Therefore, instead of attributing the patient's complaint of pain to nervousness or to want of pluck, we should always make sure that there is not some actual cause for the complaint.

Thirst. — After all operations, but particularly after abdominal operations, thirst is an early complaint and one which I believe should be satisfied by giving water by the mouth, unless it is contra-indicated and in such cases by the rectum. If the patient is vomiting, he may be given a glass of hot water which as mentioned before will result in a fair gastric lavage. It is only where vomiting is persistent, in certain operations on the stomach itself, and in cases of peritonitis that water by the mouth should be forbidden. Unless given with the idea of washing out the stomach, I think that cold water is preferred by most patients and I usually allow the patient the choice. If an operator does not believe in giving the patient water to drink, he certainly should give large quantities slowly by the rectum.

Diet.—The very old and the very young patients require earlier feeding after an operation than others and it seems to do them no harm. As a general rule a desire for food should precede its administration. It is a mistake to urge food upon any healthy patient soon after an operation, unless he really wants it. Water in good quantities is all the patient needs in the majority of instances during the first day or two, or albumen water with orange juice or orange juice alone may be given.

In regard to the liquid feeding, the patient's choice and habit should be considered, as for instance, a patient who is accustomed to drinking tea should have tea and not be forced to drink milk.

The return to a full liberal diet should be gradually brought about by following the liquid nourishment with cup custards, ice-cream, soft boiled eggs, etc. Spinach is a vegetable which is particularly useful after operation because it tends to produce movement of the bowels. Only easily digested and no rich food should be given to the patient the first week or two following operation and thorough mastication should be insisted upon. Smoking, if habitual with a patient, should be allowed as soon after operation as desired, as it produces a sense of comfort. The first request of a French soldier during the late war after operation was for a cigarette and it was always allowed him.

Rectal feeding must often be depended upon after operation and

I believe that little else than peptonized or malted milk with eggs should be given. Alcohol in any form, if long continued, produces an irritation of the rectum and an intolerance for the nutrient enema.

Bowels.—One of the mistakes of the past and still too often made is that of the excessive and too early administration of laxatives after operation. If the patient has been properly prepared for operation and has taken only liquid food, the administration of any laxative within the first few days after an abdominal operation accomplishes very little good and adds enormously to the patient's discomfort and loss of sleep. The "gas pains" which patients complain of after operation are not really due to gas, but to peristalsis and to increase this perstalsis with a laxative, when the intestinal tract is comparatively empty, does more harm than good. A small enema or the introduction of the rectal tube will accomplish more good and give rise to little discomfort. When it does become necessary to give a laxative, it should be of a mild character. For some years I have found that one of the preparations of mineral oil is very satisfactory. Milk of magnesia is another useful mild laxative in these cases. Of course occasionally when a patient has not been prepared for operation, a thorough opening of the bowels is a good thing, but to routinely administer a laxative on the second day after an operation as was formerly the custom, is a great mistake.

Bladder.—Many patients have difficulty in voiding urine, especially after abdominal operations and those done on the perineum and rectum. Excepting those cases where contamination of the wound is feared, every effort and means should be employed to make the patient pass his own urine and to avoid the use of the catheter. The patient should even be allowed to stand on his feet beside the bed in order to void, unless such a position is apt to interfere with the integrity of the wound closure and female patients should always be allowed to sit up on a bed-pan rather than be catheterized. Too frequently the catheter is passed when the patient has had no discomfort and there is no evidence of distention of the bladder and it is done simply because the patient has not voided within eight or ten hours after operation. It should be borne in mind that patients often secrete very little urine during the first few hours after operation and, when once the catheter has been used, there is a great likelihood of it having to be used again. If a patient voids once, he should be able to void afterward and the catheter should not be used unless absolutely necessary because of distention. The administration of an enema very frequently enables the patient to void and in rectal cases inability to do so is due to too tight packing of the wound or to the presence of a tube or tampon in the rectum and their removal will bring about a normal micturition.

If a patient has urethritis, the passage of the catheter is strongly contra-indicated as it is sure to result in an extension of the infection. One of the strong arguments against the use of the catheter is the danger of infection and an irritation of the urethra from continued catheterization. When catheterization is absolutely necessary, it should not be done I believe at regular intervals, but when the patient becomes uncomfortable because of a full bladder. We have all seen patients suffer great torture because the stipulated number of hours between catheterizations had not yet expired. Nothing is more uncomfortable to a patient who has been operated upon than a distended bladder and no one can predict in any given case the number of hours required to bring about an uncomfortable distention. As a rule a patient is more apt to pass urine before the bladder becomes greatly distended and it is at this time that he or she should be encouraged to do so. The character of the urine and the amount passed should be as carefully determined after the operation as before it.

Pulse, Temperature and Respiration.—In determining the value of these after an operation, it is important to have a record of them a day or two previous to operation. Nurses should be instructed always to feel and count both radial pulses, as often one of these vessels is much larger than the other.

The significance of the pulse, temperature and respirations in shock and hemorrhage are dealt with so completely in the chapters dealing with these subjects that it is unnecessary to mention it here. Axillary temperature after an operation is not very reliable and where there is an unexplained difference in the mouth and axillary temperature, it should be confirmed by a rectal thermometer. An increased respiratory rate is not given the consideration in surgical cases that it deserves and when it is not in proportion to pulse and temperature or is not explained by the character of the operation, it usually means some inflammatory condition in the lung or pleura or it may indicate an acidosis.

Time in Bed.—No definite rule can be laid down as to the number of days a patient should stay in bed after an operation. In the early days of abdominal surgery, too much restraint was put on a patient in this way and every other way, and a few years ago there was a movement which went too far in the other direction and resulted in wound infection and other complications.

The question is not how soon the patient can get out of bed, but how soon should he do so. Generally speaking he should remain in bed until his wound is healed, if it should be an abdominal wound, and if it is a large abdominal wound he should remain in bed at least a week after it has healed.

CARE AFTER RECOVERY FROM OPERATION.

Many of our finest surgical results are spoiled by a lack of care after the patient has left the hospital and simply because he has not been told what he should and should not do or has not received the late postoperative treatment which he requires.

What would be the results in our cases of exophthalmic goiter if no attention were paid the patients after operation?

I should say the two conditions most neglected after the operation were tuberculosis and syphilis. The results of surgical interference in localized tuberculosis are remarkably good and the patients usually make complete recoveries, if they carry out the proper hygienic, dietetic and medicinal treatment after operation. If these measures are not enforced, there is a fair chance of recurrence of the trouble or its development somewhere else. Syphilitic patients are too frequently operated upon and no instruction given them as to their subsequent treatment. The same applies to operations for malignant disease; the use of the x-rays after operations for cancer, and the use of the x-rays or radium with Coley's toxins after operations for sarcoma have resulted in many cures that would have never been obtained through operation only. Most surgeons are too busy to carry out these postoperative treatments, but the responsibility of seeing that the treatment is carried out is theirs.

Another important thing after operation and one generally neglected by surgeons is some plan of following up the patient in order to record the result obtained. Such a plan does more to destroy self-satisfaction on the part of the surgeon and stimulate him to better efforts than anything else.

COMPLICATIONS AFTER OPERATIONS.

Hemorrhage and Shock.—Hemorrhage and shock, two serious but fortunately not common sequels of operation have been considered in other sections of this work and it is needless to speak of them again. (Pages 117–124.)

Abdominal Distention.—Abdominal distention of some degree is common after abdominal operations but may occur after any operation or after an injury, such as a broken leg or the laceration of a kidney.

The postoperative distention may be due to a simple accumulation of gas in the intestinal tract, the result of fermentation or the swallowing of air, to a paralytic ileus, to an obstruction of the bowels (mechanical or septic) or to acute dilatation of the stomach. The simple type of moderate distention is, as a rule, easily relieved by the use of the rectal tube, change of position, the administration of a carminative or the use of an enema and as the employment of these agents has been dealt with, it is needless to consider them again, but the distention resulting from the other causes mentioned deserves more serious consideration.

Paralytic Distention.—Paralytic distention is not always due to a peritonitis as some would have us believe but should be distinguished from that form of intestinal obstruction due to peritonitis. We see the paralysis of peristalsis after operations on the kidney where the peritoneum has been subjected to only the slightest traumatism and after injuries, especially in strong muscular individuals and in the aged, when rest in the recumbent position is necessary, and in many other conditions. Although in the majority of cases the distention can be relieved in the beginning by simple means if it lasts for any length of time it becomes very distressing and possibly serious. In the postoperative cases it comes on early and is accompanied by vomiting. Its distinctive feature is an absence or marked lessening of peristalsis. There is often great difficulty in differentiating this condition from an ileus due to peritonitis but the patient does not show the other symptoms of peritonitis and the distention of a peritonitis is a late, not an early symptom, after operation, unless the peritonitis was present at the time of the operation.

Where there is a doubt as to the cause of the obstruction, that is, when a peritonitis or a mechanical obstruction is suspected, the treatment of these conditions, which is given later, should be followed, and not that to be outlined now.

Where one can be sure then that a mechanical obstruction or a peritonitis is not present relief of the distention may be obtained by attempting to stir up peristalsis by the administration of drugs and by the use of enemata. Local applications such as turpentine stupes or flax-seed poultices often give comfort and cause the passage of flatus. Enemata of soap and water with turpentine, given high, in good quantity are indicated. An asafetida enema I am sure I have seen give relief although its efficacy is doubted by many. The rectal tube or nozzle left in position for several hours, especially with the patient on his left side, when this position is not contra-indicated, is of the greatest service.

Among the drugs employed in this condition are strychnin, eserin and pituitrin. The ordinary purgatives often only increase the contents of the intestine by causing secretion from the mucous membrane and do little to produce peristalsis. I have used eserin but confess that I have not been impressed with its power. Pituitrin will certainly increase peristalsis and I have seen it cause a rapid subsidence of a distended abdomen following a nephrotomy. I should not use either of the two latter drugs for a distention coming on after forty-eight hours after an abdominal operation for fear of aggravating a peritonitis or an obstruction due to a mechanical cause. Too much stress cannot be laid on the importance of eliminating these two conditions before resorting to any measure which will increase peristalsis. C. L. Gibson[1] strongly recommends pituitrin. He urges a fresh preparation and advises "an ampoule (1 c.c.) of the preparation and repeat every hour up to three doses; subsequent doses two hours apart."

The old method of attempting to relieve paralytic distention by puncturing the bowel through the abdominal wall is certainly always dangerous and practically never efficacious. Even the opening of the abdomen and establishment of an artificial anus will as a rule only relieve the distention of two or three feet of intestine, although this is a far safer plan than puncturing the bowel through the abdominal wall, which is no longer a justifiable procedure.

Postoperative Intestinal Obstruction.—This distressing complication is not as frequent as formerly, due to the development of a more careful technic and the observance of those precautions to prevent it

[1] Ann. Surgery, April, 1916.

which have already been repeatedly referred to, particularly the avoidance of rough handling of tissues and the covering over of raw areas with peritoneum and omentum, because it is adhesions which constitute the chief cause of postoperative obstruction. Of course the cause of the obstruction may have existed before operation, such as a septic peritonitis, or may be unavoidable during the operation owing to a necessarily extensive procedure, such as the removal of a large portion of the colon or a large adherent tumor.

Mechanical Obstruction.—In this type there is definite mechanical pressure exerted upon the intestine which first prevents the passage of the intestinal contents and later produces either gangrene of the intestine or peritonitis or both. Adhesions certainly cause the majority of the mechanical postoperative obstructions and the most potent type is the adhesion of the small intestine to some fixed point, such as the abdominal or pelvic wall, the raw surface of a broad ligament, the uterine stump and the mesentery. One constantly sees numerous coils of small intestine bound together by the densest adhesions and yet no obstruction results. The degree of mobility of the structure to which the intestine is adherent then strongly determines the development of obstruction. It may be said in this connection that the surgeon is frequently surprised on opening an abdomen a second time to find that nature has done away with many adhesions which were present at the first operation and if this were not true, the number of obstructions would be greatly increased. It is also a common observation that a severe and extensive infection of short duration gives rise to fewer permanent and obstructing adhesions than a more localized or milder infection requiring prolonged drainage. Drainage itself in the absence of infection is a frequent cause of obstructing adhesions. This was seen frequently in the early days of abdominal surgery when drainage was employed after all operations.

Symptoms.—The symptoms of the mechanical obstruction are often insidious and rarely appear before the fifth or sixth day after operation and often not until much later. The first complaint is usually of paroxysmal pain and difficulty in satisfactorily emptying the bowels; this is followed by vomiting if the obstruction is high or distention if it is low. Vomiting develops later regardless of the situation of the obstruction, but distention may not be marked if the obstruction is high up in the small intestine. Visible peristalsis with distention is absolutely indicative of mechanical obstruction. It is quite evident too that the sharp paroxysmal pain is caused by peristalsis.

The patient may be relieved in the early stages by a movement of the bowels or the passage of a large quantity of gas but the symptoms are apt to recur and if they do, it is another indication of some mechanical obstruction, but it may not be so easily relieved as in the first instance. After the onset of the symptoms it is not at all infrequent to have a copious movement follow an enema or considerable gas escape through a rectal tube, but if this does not relieve the pain, diminish the distention and arrest the vomiting, it is evident that the fecal matter and gas have come from the bowel beyond the point of obstruction. One then must not be misled by the mere fact that a movement or the expulsion of gas has followed the employment of an enema or the introduction of the tube.

Septic Obstruction.—In this type of intestinal obstruction the cause is a septic infection of the peritoneum and the obstruction is paralytic or adynamic. It comes on early after operation, usually those done for a septic condition of one of the abdominal viscera or a diffuse peritonitis, or it may have existed before operation. It is characterized by persistent vomiting, restlessness, pain, apprehension, anxious expression, abdominal distention, absent peristalsis, no passage of fecal matter or flatus and later by a complete absence of pain, but unfortunately by a realization of danger on the part of the patient. The facial expression is that typical of peritonitis and near the termination the patient is apt to show a peculiarly happy form of delirium in which he may convince the inexperienced that he is much better.

Diagnosis.—It is not always easy to differentiate this type from the mechanical and the difficulty often arises because we have present both a peritonitis and a mechanical obstruction. The typical cases, however, are very different and we should always endeavor to distinguish them, for the treatment of the two differs greatly.

Treatment.—In the mechanical type, unless the use of an enema or the continuous use of a mild remedy such as mineral oil brings complete relief, operation is plainly indicated and should not be delayed. Much valuable time is lost and the patient's suffering greatly prolonged and increased by the use of purgatives and the employment of drugs to increase peristalsis. When there is evidence of a definite obstruction one should operate just as promptly as in a strangulated hernia. Delay means gangrene or peritonitis and an operation which may be only palliative or preliminary, whereas prompt action gives extremely good results when there is no infection. Before re-opening the abdomen the possibility of a strangulated hernia, particularly of a partial enterocele, should be eliminated.

The choice of the anesthetic in these cases is of great importance and, if the patient has been vomiting persistently, gastric lavage should precede the anesthetic. Whenever the patient is very ill the abdomen should be opened under infiltration anesthesia and if possible the entire operation conducted without the use of a general anesthetic. As a rule the previous incision can be re-opened, but if this is so placed as to give poor access to the region where the obstruction is suspected or is badly placed for a general examination of the abdominal cavity, a new incision should be made. These patients can usually indicate approximately fairly well by the location of the pain and tenderness the region in which the obstruction will be found. After the abdomen has been opened it is important to prevent the extensive protrusion of the coils of distended small intestine. Evisceration for the purpose of locating the point of obstruction is not only unnecessary but contra-indicated because it produces shock, increases risk of infection and subjects the distended and infected bowel to unnecessary traumatism. The site of the obstruction can usually be detected by tracing the distended bowel until the collapsed portion is encountered, or preferably by tracing the collapsed bowel up to the point of distention. By pursuing the latter plan injury to the distended intestine is less likely. One should not feel that all the adhesions encountered should be separated, but wherever the small intestine is adherent to a fixed point, such as the mesentery or the abdominal wall, it should be liberated. If the patient's condition is very bad, it may be a better plan to do an enterostomy, particularly if difficulty is encountered in finding the point of obstruction. This rule should certainly be followed in the case of the large intestine as it is a well-established rule that resections of the large intestine in the presence of acute obstruction are contra-indicated. Resections of the small intestine can be done in the presence of acute obstruction if the patient is not very ill and the proximal portion of the bowel is in good condition. The short-circuiting of the small intestine by anastomosing a coil of intestine above and below the obstruction is a feasible procedure and in certain instances where the separation of the adhesions may mean perforation of the bowel, a wise one.

The treatment of paralytic ileus due to peritonitis is the same as that of peritonitis, which has been fully dealt with elsewhere. The majority of surgeons do not as a rule recommend operative interference in these cases as the mortality is very high and as it is believed that practically as many cases recover without as with operation. Where one is unable, however, to eliminate the question of mechanical obstruction, the abdomen should be re-opened.

I believe that in these cases the best results will be obtained by following Ochsner's method of treatment in general peritonitis. C. L. Gibson in his paper already referred to in the section dealing with paralytic distention expresses great confidence in the use of pituitrin. In the septic cases I have had but little experience with it and am not in a position to recommend or decry its use.

Acute Dilatation of the Stomach.—Acute gastric dilatation or gastromesenteric ileus may occur after any operation but is most frequently seen after abdominal operations, especially those involving the bile passages. The condition is also seen in pneumonia and other diseases which are in no sense surgical. The explanations of the condition are so numerous and diverse that it may be safely presumed that there are many causes or that the true cause is unknown. It corresponds in many ways to the paralytic distention of the small intestine already described. Surgical writers have laid so much stress upon pressure by the mesenteric vessels upon the duodenum as a cause that the term gastromesenteric ileus has become synonymous with acute dilatation of the stomach. The dilatation has, however, in too many cases stopped short of the mesentery and its vessels for this term to be considered generally applicable.

In septic cases the condition is often associated with general distention of the small intestine and the paresis of the stomach like that of the intestine is due to infection but it is seen too frequently in clean cases and where no operation has been done to explain all cases on this basis. The following paragraph from Crandon's *Surgical After-treatment* gives a good idea of the variety of supposed causes: "It is said to be common in thin, weakly individuals, especially those with general enteroptosis. Abdominal trauma, errors of diet, the accumulation of gas due to fermentation of retained foods, drinking large quantity of fluids, especially carbonated waters, and tight abdominal binders have all been blamed as the source of this complication. Connor makes the statement that obstruction of the duodenum by the overlying mesentery must be regarded as a factor in the development of one-third to one-half of all cases of acute gastrectasis, and Polak states there can be no doubt but that the Fowler posture favors constriction of the lower end of the duodenum between the root of the mesentery and the vertebral column. Peritonitis may be a factor in certain cases."

Bloodgood[1] discusses the subject at length and considers mesenteric pressure at the juncture of duodenum and jejunum the commonest cause and reports several cases.

Chloroform anesthesia and pyloric spasm are two other causes which have been suggested.

The whole subject has been exhaustively dealt with by Lewis A. Connor[2] of New York, and later by Laffer[3] who has collected 217 cases and gives an extensive bibliography.

Vomiting is the most common and pronounced symptom although it has been absent in a few cases. The profuseness of the vomiting is distinctive and has usually been persistent, although intermittence has been noted and the vomiting is apt to cease some hours before death. The fluid vomited is bile-stained and has a sweetish odor. It is never fecal.

The distention is characteristic in the typical case, it is first noticed in the epigastrium and extends then to the left side. In the early stages the lower abdomen remains flat or even scaphoid, though the stomach has in one or two instances been so dilated as to fill the entire abdomen. The succussion splash can usually be detected. Pain or a sense of great discomfort in the epigastrium is a more or less constant symptom. The facial expression denotes distress and anxiety and hiccough is often present. Constipation is the rule but in a few cases there has been a marked diarrhea. A visible peristaltic wave has been noted by Bloodgood and others but it has not been a common sign. The pulse-rate increases with the distention but the temperature remains normal or subnormal. Respiration is rapid and embarrassed and dyspnea may develop. Nearly all observers have referred to the complaint of great thirst. Collapse may supervene in twenty-four or forty-eight hours after the onset of dilatation, but many cases have extended over a number of days and relapses are reported even after an apparent complete recovery.

[1] Ann. Surg., 1907, xlvi, 736.
[2] Am. Jour. Med. Sc., 1907, cxxxiii, 345.
[3] Loc. cit.

Prognosis.—The prognosis is very grave in this condition. Laffer gives the mortality in his collection of 217 cases as 63.5 per cent. A study of the reported cases goes to show that the mortality is influenced very largely by the promptness with which the condition is recognized and the persistence with which the stomach tube is employed.

Treatment.—As might be expected from a consideration of the many causes of the condition, the treatment is more or less unsettled. The repeated employment of gastric lavage regardless of the seriousness of the patient's condition and continuous enteroclysis constitute the most valuable means we have of relieving the condition. Great stress has been laid by a number of writers upon the importance of keeping the patient either in the prone position or on his right side and many recoveries have been attributed to the avoidance of the dorsal position. It seems hardly necessary to state that nothing whatever in the way of food, drugs or drinks should be given by the mouth. Although various operative procedures have been undertaken for the relief of acute dilatation, gastro-enterostomy is the only one which would seem feasible but even after its performance the repeated use of the stomach tube may be necessary as the new stoma does not always drain the stomach. In fact one case has been reported where fatal dilatation followed gastrojejunostomy and at the autopsy the new opening as well as the pylorus showed no obstruction.

I am inclined to believe that a successful treatment of these cases depends upon the early recognition of the condition and the prompt and repeated use of the stomach tube.

Hiccough.—Hiccough often becomes a distressing postoperative complication but it cannot in any sense be attributed to the operation in most cases. This spasm of the diaphragm is reflex and is due to irritation of the pneumogastric or phrenic nerves. It is seen usually where there is an inflammation in the structures supplied by the nerves, but it often occurs where no such condition can be demonstrated during life or at autopsy, for occasionally it alone is responsible for death. The surgeon sees it usually in cases of peritonitis and after operations on the upper abdomen. I have seen persistent hiccough follow two cases of gunshot wound involving the diaphragm; both patients recovered.

Treatment.—No reliable method of treatment can be given. It is well first to eliminate any discernible cause of irritation in the gastro-intestinal and respiratory tracts which may possibly cause the condition. Such simple means as holding the breath and drinking water or semifluids, which are efficacious when hiccough occurs in health, may be employed first and later compression of the lower thorax and abdomen by a tight bandage or the hands. Antispasmodic medicines may also be employed and I think it is important to see that the patient gets either by the mouth or rectum large quantities of water.

Acidosis.—This question has become one of practical importance to the surgeon in estimating the risks of operation and in the pre- and postoperative treatment.

Acidosis, acetonuria or acidemia first engaged surgical attention when it was shown to follow the administration of a general anesthetic, especially chloroform and particularly in children. The "late chloroform poisoning" which has long been recognized and variously explained is acidosis. Ten years ago the surgical literature teemed with reports of postanesthetic deaths due to acetonuria and postoperative diabetic coma. An enormous advance has been made in our knowledge of this important subject by the work done in the laboratories of physiological chemistry and experimental surgery. Crile has probably done more than anyone else in this country to put this matter before the surgical profession and his laboratory and experimental work has the advantage of being supported by a large clinical experience.

It is probably safe to say that a certain degree of acidosis exists for a limited period of time after any surgical operation which necessitates a general anesthetic (of whatever kind), produces pain, or occupies any length of time, and is manifested by rapid respiration, sweating, late or persistent vomiting, the odor of acetone on the breath, increase in pulse-rate, great thirst, and the presence of acetone and acid bodies in the urine. In the more marked cases which we designate as toxemia, the symptoms are persistent, very much increased and the patient is apt to pass into a coma and die.

Anesthetics and surgical operations are not the only causes of decreased alkalinity of the blood, for Crile and others have shown that exertion, emotion, injury, infection, auto-intoxication, Graves' disease, etc., may cause it. He[1] says of his studies of this subject that "they determine that the brain, the adrenals, the liver, the thyroid, and the muscles together play important parts in energy transformation, and that at least three of these organs, the brain, the adrenals, and the liver, are especially concerned also in the neutralization of the acids resulting from energy transformation," and again "if in a certain case there is shown a continuous increase of acid by-products for the neutralization of which an unusual amount of alkali is required, then we may presume the liver, the adrenals, and the brain are undergoing abnormal changes; and that unless the acid condition be altered, these structural changes in the brain, the adrenals, and the liver will become permanent and certain of the chronic diseases will result."

That all general anesthetics produce acidosis is also testified to by Crile who says that "nitrous oxid, ether and chloroform during their administration all produce increased acidity of the blood. In our experiments we have found out recently the additional fact that the acidity of the urine is increased markedly under ether and chloroform and less under nitrous oxid. This finding has a most important significance for the surgeon, as it explains why the administration of the anesthetic to a starved patient with gastric or duodenal ulcer, for example, may cause death by precipitating the impending acidosis." I might add that chloride of ethyl which I have used extensively during the past fifteen years is no exception to the rule.

[1] Tr. Am. Surg. Assn., 1915.

With these evidences of the cause or causes of this common postoperative condition, we should pay some attention to the subject in preparing our cases for operation and in endeavoring to prevent or limit the postoperative acidosis.

First we should do everything to eliminate fear, avoid starvation, give plenty of water, traumatize tissue as little as possible, make our anesthesias as short as possible consistent with thorough surgery, and exercise a choice of anesthetics.

The treatment of acidosis can be expressed in two words: water and alkalis; the one hastening elimination of the acids and the other neutralizing them. Soda bicarbonate is the simplest and best alkali and can be given by the mouth when vomiting is not marked and the symptoms not severe. Twenty or thirty grains should be given every hour or two. Subcutaneous administration may produce irritation and abscesses. In most cases the rectum is the best avenue for this medication which should be given by the continuous "Murphy drip" method. Three or four hundred grains a day is not too much. Carbohydrates are also indicated in the postoperative treatment of this condition.

In all cases after a prolonged anesthesia, in severe shock after the loss of considerable blood and whenever an acidosis might naturally be expected, bicarbonate of soda and large quantities of water should be given by continuous enteroclysis.

Thrombophlebitis—Pulmonary Embolism.—Thrombophlebitis is a fairly common postoperative complication, especially after operations upon the female pelvic viscera and rectum. It is also seen occasionally after operations for hernia and appendicitis. Anemia particularly favors this complication and consequently it is seen more frequently after operations for fibroid tumors which have caused profuse bleeding. General debility of the patient also predisposes to the condition.

As a rule thrombophlebitis does not occur until about ten days have elapsed after the operation and often not until the patient gets out of bed.

The veins most frequently involved are the pelvic tributaries of the iliac, the long saphenous, especially the left, and the femoral. The condition is not in itself serious and recovery as a rule is complete but there is always the possibility of the detachment of an embolus with its subsequent lodgment in the pulmonary circulation. A less serious and more frequent result of thrombophlebitis is varicose veins. The frequency of the condition in the pelvic veins is indicated by the casual finding of phleboliths in *x*-ray plates of the pelvis. These phleboliths represent the calcification of a thrombus. Although permanent occlusion of the vein by the clot and conversion into a fibrous cord is a common result of thrombophlebitis, in many cases complete blocking of the vein does not occur and the normal caliber is reëstablished through absorption and repair.

The cause of thrombophlebitis has been a matter of much discussion. Most authors, however, agree that infection is the most common factor. Da Costa[1] says "In the formation of thrombi four conditions are to be considered, viz., chemical alterations in the blood, a bacterial attack on the intima, tissue changes in the inner coat of the vessel, and slowing of the circulation. . . . The essential cause of all intravascular thrombi is damage to the endothelial coat and in most instances the damage is effected by bacteria, hence most cases of thrombosis seen by the surgeon are infectious."

It cannot be denied, however, that thrombosis frequently occurs in patients who show no evidence whatever of any septic process.

Of the symptoms pain, tenderness and edema are the most conspicuous. When the leg is involved the patient usually complains of pain in the calf and over the long saphenous and pressure in these regions reveals great tenderness and in a short time the leg becomes edematous. There is a moderate rise in temperature and a considerable increase in the pulse-rate. In the septic cases the symptoms are often preceded by a slight chill or chilly sensations.

In the case of the pelvic veins, vaginal or rectal examination reveals tenderness and edema and if the iliac or femoral veins become subsequently involved edema of the extremity occurs. Extension of the process from one extremity to the other is by no means infrequent. there usually being an interval of several days between the two involvements. With complete thrombosis of the superficial veins one is able to palpate them easily and the tributary veins are often markedly distended.

Under proper treatment the acute symptoms subside in a few days but the swelling may not disappear for two or three weeks. If the patient is allowed to get out of bed before the condition has entirely subsided there is a rapid recurrence of the edema.

The treatment consists in absolute rest in bed with moderate elevation of the part and the application of an ice-bag. Many surgeons prefer to apply heat but I have certainly had more satisfaction in the use of the ice-bag. An absorbent ointment of belladonna and ichthyol seems also to give comfort, especially where the superficial veins are acutely inflamed, as indicated by a redness of the overlying skin. The patient should not be allowed to become constipated but the bowels should be kept open by either mild laxatives or the use of enemata. Massage of even the lightest character, which the patient often asks for, should never be permitted because of the likelihood of detaching a portion of the clot. The patient should be kept in bed for at least ten days after the subsidance of all symptoms. Many cases of fatal pulmonary embolism have occurred on the day the patient first gets out of bed.

It has been suggested by many surgeons that ligation or ligation and extirpation of thrombosed veins should be done in order to prevent the serious complication of pulmonary embolism. Although such procedures might prevent a catastrophe in rare instances, its use in all cases would certainly seem to be unjustifiable.

[1] Modern Surgery, 7th edition, p. 185.

Pulmonary Embolism.—Pulmonary embolism is caused by the dislodgment of a clot or portion of a clot which is blocking one of the veins and which finally lodges in one of the bifurcations of the pulmonary artery. If the clot is a small one it may not lodge until it reaches the smaller branches of the pulmonary and, if no large clot forms behind it, the portion of the lung supplied by the branch becomes ischemic and an infarct develops. If such a small clot is septic, a septic pneumonia results. If the larger branches of the pulmonary artery are blocked by the embolus a rapid clot forms behind it and the patient will die within a few minutes or within a few hours. Lodgment of small emboli in the pulmonary circulation is probably more frequent than is generally supposed and often is not recognized, although the physical signs are usually distinct after a day or two. The serious type of pulmonary embolism is by no means rare and is a common cause of sudden death after operation. Such a catastrophe may take place a day or two after the operation or may not occur for several weeks as it usually follows a recognized thrombophlebitis. It frequently occurs after abdominal operations, however, where there has been no evidence of thrombophlebitis. It is probably the most rapidly fatal and most distressing postoperative complication.

Symptoms.—The symptoms are unmistakable, the patient being suddenly seized with a sense of suffocation or pain in the chest with rapidly failing circulation and marked dyspnea. Anxiety, apprehension and restlessness together with a sense of impending death are present. In practically all cases these symptoms are rapidly followed by dilatation of the pupils, cold sweat and unconsciousness. The patient may die in less than a minute or may survive for several hours.

Treatment.—The treatment is most unsatisfactory and consists in the administration by hypodermic of cardiac and respiratory stimulants, particularly camphor and ether, in the employment of artificial respiration, and in the use of morphin and atropin.

Wherever a thrombophlebitis is present one cannot be too careful in seeing that the patient avoids any strenuous movement or straining and that he does not get out of bed for ten days or two weeks after all symptoms have subsided. This care will be appreciated when it is remembered that the catastrophe has occurred in many patients when they have first sat up in bed or on their first day out of bed.

The operative treatment of this condition remains sub judice. Trendelenburg was the first to suggest and practice the removal of the clot from the pulmonary artery and has performed the operation several times. In none of the cases has it been successful although two of the patients have survived the operation. The pulmonary artery is exposed by resecting the second rib and opening the pleura and pericardium; it is then incised, the clot extracted and the wound closed. In order to successfully accomplish the operation it should be carried out with the greatest promptness and celerity. I know of no complete recovery following this operation and the only warrant for its performance is the universally fatal result which follows the occlusion of the pulmonary artery by a clot.

VACCINES.

By A. F. JONAS, M.D.

GENERAL STATEMENT.

We must guard against the optimism of certain enthusiasts in vaccine therapy who look upon every recovery from an infection, as being brought about by vaccine which they may have administered. The experienced practitioner who had become familiar with infections long before the advent of vaccines, has been among the first to note that the majority of infections are self-limited and end in recovery quite as promptly as those cases in which the vaccine therapy has been used. Therefore, many of the claims made for the advanced therapy are not borne out by every-day experience. But to discredit the entire method, as is done by some, is not warranted. That the underlying principles appear to be well founded, but there is something wrong with the method, is well expressed by Hektoen. He states: "The simple fact is that we have no reliable evidence to show that vaccines, as used commonly, have the uniformly prompt and specific curative effects proclaimed by optimistic enthusiasts, and especially by certain vaccine makers who, manifestly, have not been safe guides to the principles of successful and rational therapeutics."

We know from everyday experience that if we carefully search for the source of the infection and relieve the primary focus by local treatment, as for example, a thorough disinfection at the port of entry, the free evacuation of localized infectious material in the form of pus or any foreign substance facilitating free drainage, the absorption of toxins will cease and bacterial propagation will come to an end without further systemic treatment. The normal immunization mechanism will rapidly eliminate and bring to an end bacterial propagation and their products.

Wright made a determined effort to place vaccine therapy on an exact basis. His discovery of opsonins and the use of the opsonic index as a guide to the administration of vaccines was an encouraging move in the right direction and was at first generally accepted by the profession. The painstaking and exact microscopic training and laboratory equipment that the method required was found to be impractical for the general practitioner, and it soon fell into disfavor. Further, laboratory experts questioned the accuracy of the method and it was not regarded as essential by many practical workers. Very soon stock vaccines came into general use. Their effects appeared doubtful and the whole method became discredited. However, enough of the principles of their action was known to be well founded in that certain investigators pointed to the fact that a vaccine should be made from microörganisms taken from the individual suffering from the disease, and they insisted on autovaccines. The preparation of autovaccines, however, must ever be regarded in the majority of infections as the only exact and scientific method in the use of vaccines. When we pursue the reports of Rosenau wherein he shows the frequent and almost constant change in the strains of bacterial growth, we are impressed with the necessity, if vaccines are at all useful, of making vaccines from the blood or pathogenic products of each individual who is being treated. No two individuals are affected by or react to a given bacterial toxin in precisely the same way.

It is clear that each individual harbors microörganisms that are specific to himself, and must differ from those of every other individual. Therefore, to obtain the best possible results, each individual must furnish his own vaccines. But to do this is clearly beyond the general practitioner and most hospital attendants. When this fact was realized, especially in our country, it was not long before there was an unrestrained and indiscriminate exploitation of vaccines by certain makers. The profession was easily persuaded to employ the many products put out by commercial firms. Autovaccines rapidly gave way to stock vaccines. The commendable efforts to secure exactness soon were displaced by routine and guesswork. Commercial concerns became the educators in vaccine therapy. The fundamental principle that vaccines must contain bacteria that are exactly or nearly identical with the strains causing the infection was forgotten. It is clear that with vaccines made in large quantities, this condition cannot be maintained. "The changes in virulence and affinities which take place in bacteria under artificial cultivation cannot be avoided." (Hektoen.) It cannot be expected that the specific element on which the desired antigenic effect depends is still existent.

The wholesale producer of vaccine soon evolved a shotgun vaccine which he termed a polyvalent vaccine, which contained all manner of strains of nearly the whole group of pathogenic bacteria. But, after all, like the shotgun prescription of old containing many drugs, this is a poor substitute for a specific autogenous vaccine. The use of an autovaccine means a careful study of the case under treatment. It means an exact diagnosis. If it is true that every microörganism produces its own antibody, an etiological diagnosis is imperative. It is owing to this last essential that the autovaccine therapy has been robbed of its practicability. Because physicians are either not equipped or not trained and also lack the time to make an etiological diagnosis, the mixed unstandardizable vaccines—phylacogens—have enjoyed more or less popularity. These preparations have no antigenic value and are, at best, only poor uncontrollable makeshifts. The tendency of the medical attendant is to become more superficial in the examination of his patient and subsequently his diagnosis is more inexact.

The tendency to the employment of vaccines in all forms of infections, both acute and chronic, the vast majority of which are self-limited, is to be deplored. This practice has given rise to undeserved praise of many vaccines that really are inert and ineffective and leads to erroneous conclusions. Its tendency is to discredit the entire vaccine therapy in the minds of many observers.

While we have met with many disappointments, we must ascribe the failures to the methods of their employment. Vaccine therapy is of undoubted value as has been shown by its employment in typhoid by Fraenkel, Ichikawa and in pneumonia by Rosenow and others. And more recently as prophylactic in tetanus, especially in the late European war. The method is of undoubted value and has found a permanent place in our armamentarium in the treatment of certain infections. At present, the main facts are obscured by a mass of uncertain and ill-considered theories and faulty application. But we are in possession of sufficient facts that will enable us to make intelligent use of vaccines in certain well-selected cases. While we may accept the teaching that all vaccines should be made from the microörganism causing the disease in each individual, which is especially true in acute cases, we cannot condemn all stock vaccines. Occasionally the use of the latter has been followed by prompt results. In the absence of time and a proper equipment for the production of autovaccines, stock vaccines may be resorted to providing an exact diagnosis, either clinical or bacteriological or both, can be made.

We must not lose sight of the fact that within the human organism, there exists a self-immunizing power that is responsible for spontaneous recovery from bacterial disease. There is a cellular mechanism that exerts a destructive effect on bacteria.

The human organism is constantly exposed to the inroads of bacteria of various kinds. As long as the immunizing or protective mechanism can cope successfully with the invading organism so long we have health; if the protective mechanism fails and the microörganisms are not inhibited, we have disease.

Artificial stimuli may so affect the immunizing processes that individuals may become immune to a certain disease by inoculation with specific antitoxins. Persons may be made immune to smallpox, typhoid, rabies, diphtheria and other diseases by the use of artificially prepared vaccines and serums that contain antibodies which are specifically antagonistic to organisms found in each disease.

The animal organism adapts itself to various noxious conditions by a gradual process of elaborating bodies antagonistic to them.

While studying the process of immunization and particularly the ways of increasing the power of the immunizing mechanism, we must not forget that there are several processes, besides vaccines, that play an important role. The removal of foreign bodies, elimination of infectious material by drainage, germicides or antiseptics, cellular infiltration and the flow of blood to the seat of infection known as active and passive hyperemia which may be increased by massage suction, antitoxins, vaccines and bacteriotropic chemicals, all of these may be aided by hygienic measures.

Animal experiments have proved that gradually increasing doses of a given poisonous substance, by a process of adaptation of the immunizing mechanism, will enable the animal finally to tolerate amounts that would have proved fatal if given as an initial dose.

When recovery from an infection takes place, we assume that the immunizing mechanism is producing an antitoxin of sufficient power to neutralize the toxin that circulates in the body fluids. If we inject an artificial antitoxin, we add to the already existing antitoxins and in that way relieve the excessive strain put on the body cells.

There are other substances aside from toxins that protect the body. There are a number of substances classed under the head of antitropin that play their role in the protective process. We find that they exert their power against microörganisms, each in its own way. We find that such organisms, as found in typhoid and other diseases, when killed and then injected into the body already infected with the same organism, have acquired the power of agglutinating and liquifying these organisms and destroying them. We speak of these substances as agglutinins, bactericidins and bacteriolysins. The role of these antibacterial bodies is an important one in the control of many infectious diseases.

There is another factor aside from antibacterial substances known as opsonins that seem to bear a close relation to leukocytes and phagocytic cells. The opsonins seem to prepare the bacteria so that they are more easily taken up by the phagocytes and destroyed. Therefore, we find that the antitropin, the opsonins and the phagocytes have a destructive effect on all forms of pathogenic bacteria.

In the light of our present knowledge, we may assume that phagocytosis and opsonins are the chief factors in establishing the line of first defense against invading bacteria.

According to Wright, opsonins probably develop from the connective-tissue cells, and are produced by a stimulation of specific poisons forming protective substances. These protective substances may be regarded as free receptors which destroy bacteria. Opsonins and other antibacterial substances are formed by an inoculation of killed cultures of vaccines. New substances are formed which play their role in the disintegration of bacteria; these new substances are known as antibodies, bactericidins, agglutinins and opsonins, they are taken up in the blood stream and find their way to all parts of the body and to the foci of infection and unite with the bacteria causing their destruction.

When bacteria enter the subcutaneous or submucous connective tissues they encounter the first active defenses in the form of opsonins and phagocytic cells. The fact that general systemic infections must be frequent, suggest that the body possesses defenses greater than can be furnished by the usual opsonins and phygocytic cells at the point of infection. We find that the usual defenses are enhanced by an active hyperemia, a reaction known as inflammation. The increased blood flow carries an increased amount of antibacterial bodies and fresh leukocytes. This process is prompt and efficient in the innumerable instances where bacteria penetrate the connective tissue. Should this united phenomenon of active hyperemia fail, the first defenses would yield, then infectious diseases would develop. If the virulence of the invading bacteria is of such a great degree or their numbers are greater than the active hyperemia is capable of controlling, the defenses are defective. All observations tend to confirm the accepted facts that the reaction developing immediately after the entrance of an infection known as inflammation, is essentially a protective process in all its phases.

Of recent years, a method of prophylaxis and the treatment of certain diseases with vaccines has become popular and has been practised with more or less success. This method consists of the use of certain agents that have become known as vaccines. The term vaccine is derived from the Latin word *vacca* (a cow) and refers to the "cow disease" or cowpox and has been called vaccinia. Jenner described his discovery as a protective inoculation against smallpox with cowpox virus and termed the method vaccination. The terms vaccine and vaccination do not accurately describe the material used in treatment of all infectious diseases. Jenner, being acquainted with only one form of disease and its treatment, naturally applied the term suitable to his epoch-making method. Perhaps out of respect for the great Englishman, later investigators, chief among whom was Pasteur, adhered to it and applied the term vaccine to emulsions of dead and attenuated bacteria. While the term vaccine is not accurate, in a modern sense, it has crept into the nomenclature that deals with agents which are made up of bacterial suspensions used for the purpose of creating immunization.

In connection with the study of vaccines, we must, first of all, make clear to ourselves, that they operate by effecting a condition known as immunization. The study of immunity occupies a place of first importance in the consideration in the well-being of the animal economy. We cannot overrate the immunity that is natural or physiological. It not only gives the protection against bacterial invasions that are constant, but it protects against the occasional inroads of special forms if not too numerous or too virulent. Natural immunity is relative but not absolute. There is a constant conflict between body cells and bacterial invaders but, under ordinary conditions, the body cells contend with success. This is known as natural resistance or physiological immunity. But if the organism becomes weakened from any cause and its natural defenses become defective, the bacterial hordes are overwhelming, we have disease.

We may establish a lasting immunity by a process of adaptation.

If our body cells are vigorous and active, we may establish an *active immunity.* This may be done when certain cells produce certain antibodies that neutralize special bacteria or pathogenic agents. It is well known that a permanent degree of immunity is usually established after a recovery from certain acute affections; among these we may name measles, scarlet fever, smallpox, typhoid and typhus fevers. These are among those infections where the immunity is considered permanent. Among other infections are created an uncertain immunity if it exists at all which may be of short duration and, in some instances, appears to have created a state of hypersusceptibility.

The severity of the disease does not always give us a clue to the probable degree of lasting immunity. A mild form of the disease may produce a permanent immunity and, in some instances, a severe attack of a disease does not confer a lasting freedom. It is, however, a well-established fact that in general an active immunity is established with the use of a modified antigen that will produce specific antibodies without affecting the general health of the subject.

History.—Our present-day vaccine therapy began with the vaccination against smallpox by Jenner. Prior to the discovery of vaccination, and since it was the custom in many European countries to expose children to mild cases of smallpox so that a mild form of the disease might be acquired, usually insuring a permanent immunity. This practice was not without its dangers, for it was not uncommon that a mild form of the infection became severe. It had become well known that milk-maids and others milking cows, whose hands had become infected through small abrasions with cowpox were immune to smallpox.

In 1796, Edward Jenner announced that when a human being was inoculated with a very small amount of cowpox virus, it produced a mild form of the disease and that this was followed by absolute immunity for long periods. It was shown that when smallpox virus was passed through a cow, it became so attenuated that it would not produce the typical disease, but that it had the power to produce a substance which insured freedom from the disease.

Jenner had made the practical observation that smallpox could be prevented, but he did not know how the immunity was brought about.

It was Pasteur, in 1879, who showed us by his experimental work that the virulence of microörganisms could be modified by exposing them to light, high and low temperatures and, further, that prolonged cultivation could so modify their virulence, that they could be injected into an animal without ill effects and at the same time bring about an immunity by stimulating the protective mechanism of the host.

Pasteur was aided by an accidental discovery while working with chicken cholera. He was obliged to interrupt his work by an absence from home. On his return he discovered that his cultures had lost their virulence, that hens were not greatly affected by the introduction of a quantity that had formerly been a fatal dose. The discovery that a prolonged cultivation of microörganisms would attenuate them was very great. It occurred to him that in this way a mild form of the disease could be produced and that fowls might be given a quantity to prevent a severe attack of the disease. His future work proved the correctness of his conjectures. He found that by attenuating the virulence of bacteria and their products, the body cells could be so stimulated that they produced antibodies that would protect the organism without producing the actual disease. All the later work of bacterial therapy and prophylactic immunization, rests to a large degree on these discoveries.

Side Chain Theory (Ehrlich).—In 1896 Fode demonstrated that rabbits' blood in a test tube free of cells and phagocytes, will destroy anthrax bacilli. This led Buchner to the belief that the bactericidal action of blood *serum* was due to a special body that he called Alexin.

Fresh support was given to this theory by the discovery of antitoxin by von Behring, chiefly in diphtheria.

Pfeiffer in 1894 added support to the humoral theory by showing that cholera vibrios when introduced into the peritoneal cavity of a guinea-pig, previously immunized against cholera, became liquefied apparently without the aid of cells (bacteriolysis). Bordet found a "sensitizing substance" which exists in immune serum and acts on the bacteria against which the animal has been immunized. A second body was shown to exist in nearly al animals which he called Alexin, which Ehrlich later designated as *complement*.

Then followed the attractive "side chain theory." Ehrlich attached two functions to a cell. First certain cells, like a nerve cell conducts; a gland cell secretes, this he called the physiologic function. Second, each cell has the function of nutrition, waste and repair. The latter has to do with immunity. He believed that molecules of food were seized from the surrounding tissues by a "selective action or chemical affinity between food atoms and the portion of a cell or side chain for which it has a chemical affinity." By this theory Ehrlich sought to explain the action of toxins and the production of antitoxins. He assumed that numerous side-arms receptors belong to every cell molecule. Special cells anchored special toxins. When combined with side arms or receptors in sufficient quantity, the toxins may destroy the cell, and if a sufficient number of cells are killed, the death of the host may ensue. The cells produce receptors in large quantities and are thrown off in the blood stream. Each thrown off receptor retains the same function of the original receptor, they become free receptors, and they combine chemically with their specific antigen neutralizing it and rendering it harmless. The antitoxin consists of cast off receptors, or antibodies. The antigen must possess sufficient toxic power to stimulate the cells in order that sufficient antibodies may be produced.

Following these epoch-making discoveries, an endless amount of work was done. While many modifications and amplifications have followed, the fundamentals have remained unchanged. It was shown that disease might be prevented by so cultivating a strain of pathogenic bacteria and modifying and attenuating it that it might be injected and produced in an extremely mild form of the disease without producing harm, by establishing an immunity by the production of antibodies.

All earlier work in immunity was done on animals and all experimental work of a similar character was done in the same way before being tried on the human being. Pasteur prepared a vaccine of anthrax bacteria by attenuation and exposure to elevated temperatures for varying periods of time. The same researcher soon published his discovery of modifying sections of the spinal cord of infected rabbits who had been infected with hydrophobia, by a process of drying. Out of this method was developed a prophylactic that immunized against the disease. Other vaccines were first produced in his laboratory which seemed to accord with the principles that he had laid down.

SERUMS.

Definition.—We must not confuse serum with vaccine therapy. By serum therapy is understood a process of passive immunization for the purpose of inducing a protective or curative condition. A serum is obtained from an animal that has been immunized by the injection of bacterial toxins or the microörganisms themselves. The blood of the immunized animal is withdrawn and blood serum only is injected into the subject that is to be immunized.

VACCINES.

Definition.—Vaccines or bacterins used for therapeutic purposes are made by the injection directly into the patient of pathogenic bacteria, modified by certain processes. The difference between serums and vaccines must not be lost sight of and we must not forget that a serum, as used here, is an actively immunized filtered blood-serum free from bacteria. A vaccine is composed of an emulsion of attenuated or dead bacteria. Therefore vaccines and serums are not synonymous terms.

General Principles in the Preparation of Vaccines.—Most observers are now agreed that the special microöorganisms contained in a vaccine should receive the least possible modification or just enough to deprive them of their disease-producing power. Any given vaccine should be prepared by suspending a given strain of microörganisms in a salt solution or other vehicle and then expose them to a degree of heat that will so change them that they will proliferate no longer. Great care must be exercised during the heating process for it has been shown that when too much heat has been applied the vaccine loses its immunization qualities.

There are several ways that immunization may be produced both for prophylactic and active purposes.

I. Living organisms may be introduced into the human organism. This method has not been generally adopted, for the reason, that the technic for their safe use is not fully established. The results are not uniform and there is still much experimental work necessary before a standard will be worked out so that the method may be used safely by the profession.

II. Modified or attenuated microörganisms are now more generally in use. They are prepared by one of the following methods:

1. The microörganisms are passed through lower animals by injecting them into the general circulation.
2. The most frequent method of preparing vaccine is by suspension of microörganisms that are exposed to heat after being grown on culture media, and then are modified by heat to a point at or just short of producing their deaths. Long exposure to cold may attenuate the organisms in the same way. Whichever method is used, exposure to heat or cold, great care must be exercised to avoid actual microörganic death because a suspension of dead organisms under some conditions may have no more effect than the salt solution in which they are suspended.
3. Microörganisms are attenuated when exposed to light and air (chicken cholera).
4. Microörganisms are attenuated when they are dessicated or dried. The longer they are dried the greater the attenuation (rabies).
5. Some vaccines are prepared by exposing microörganisms to elevated temperatures for varying periods of time (anthrax).
6. Chemical germicides are employed to modify certain microorganisms (anthrax—Roux) (diphtheria—Behring).

III. Bacterial constituents, the soluble toxins and products of bacterial autolysis as used by Koch in the preparation of tuberculin, etc.

LIPOVACCINES.

The success of prophylactic vaccines in a number of infectious diseases is acknowledged by all well-informed practitioners of medicine and surgery. One of the drawbacks has been the more or less severe local and general reactions in some cases after the initial dose, so that many cases refused to return for subsequent inoculations. The profession knows that in 1885, Ferran in Spain, vaccinated many thousands against cholera; in India, Haffkine successfully dealt with plague and Shiga in Japan with excellent results inoculated against dysentery. The epoch-making results obtained in our Army with typhoid and paratyphoid vaccines are well known. The severe reactions sometimes observed have created much prejudice in the popular mind.

Various expedients have been employed to solve the problem among them Le Moignie and Piony substituted oils for physiologic sodium chlorid solution commonly employed in making vaccines. The term lipovaccines has come into general use. The lipoid oil menstruum carrying the vaccine seems to delay the absorption so that the system is not so suddenly overwhelmed. Le Moignie and Piony demonstrated that three and four of the usual doses of lipovaccine, could be injected without marked reaction producing an immunity equal to that of repeated injections of the usual saline vaccines. Further, it was shown that vaccines made with oil, do not deteriorate and have the further advantage of enabling the safe use of mass injections when so desired. Several lipovaccines have been produced. There is no doubt that vaccines in oil will answer some of the objections that have been urged against the vaccine treatment of several infectious diseases.

OPSONINS.

While our early ideas of immunization were so closely linked with Metchnikoff's idea of phagocytosis, we were very soon obliged to modify these views because it was shown that substances in the body fluids increased the phagocytic process. It was observed that when leukocytes were deprived of their fluids they became powerless to take up and destroy the pathogenic microörganisms. If they were placed in fresh serum, their phagocytic power was restored. Metchnikoff believed this power to be due to a body that he termed "stimulins" and believed they changed leukocytes to phagocytes. This view was given up for a later observation which seemed to show that the phagocytes were not facilitated to increase their powers to take up bacteria but that the microörganisms were prepared so that they could more easily be taken up. Denys and Leclef, 1895, suggested that these bodies in the serum neutralized the exotoxins and endotoxins of bacteria that caused a negative chemotactic influence, in that way deprived them of two resisting powers exposing them to increased phagocytosis.

In 1903 Wright and Douglas again demonstrated that phagocytosis was increased when bacteria were subjected to the action of serum. They first determined that phagocytosis depended on some specific substance in the blood and further that the bacteria themselves were acted upon, so that they could more easily be devoured by the leukocytes. This substance they named opsonin. This body is a constituent of normal serum. Neufeld and Rimpan obtained similar results in working with immune serums, they named this substance bacteriotropin.

Definition.—Opsonins are substances in normal and immune serums which act upon bacteria and other cells in such a manner as to prepare them for more ready ingestion by the phagocytes (Kolmer). Opsonins are found in varying amounts and of different varieties for different bacteria in normal serum. Apparently opsonins are more or less specific for different bacteria. All bacteria are not equally prone to opsonification. The profession generally recognizes the importance of opsonins in their relation to phagocytosis in the process of immunization.

Wright and Douglas, who have greatly illumined this chapter by their researches, have perfected a technic for detecting the presence of opsonins and their quantity in the body fluid and, further, a method for increasing the opsonins and thereby the phagocytic process which they have designated by the opsonic index.

Opsonic Index.—According to George P. Sanborn, Wright's method of determining the opsonic index is as follows: "Into a capillary pipet, with a rubber teat affixed, are drawn equal volumes of the blood serum of a normal individual, of blood corpuscles which have been washed free from serum, and of an emulsion of bacteria against which it is desired to determine the opsonic power of the patient's serum. Each of these three volumes is drawn into the pipet separated by an air bubble, and then expressed upon a slide, mixed thoroughly, drawn into the pipet again. The pipet is sealed in a flame and incubated for fifteen minutes at 37.5° C.

A similar procedure is carried out, using the same corpuscles and the same emulsion of bacteria, but the patient's serum instead of the normal, and incubation is carried out for the same length of time. These pipets are removed at the end of the incubation period, the small end broken off and the contents expressed upon a clean slide, mixed thoroughly and a small drop of this mixture placed upon a clean slide and a smear made. Each of the mixtures is treated in this way. If the smears are then stained and the leukocytes scrutinized, it will be found that they have ingested numbers of bacteria in each of the specimens. All bacteria contained in 100 leukocytes in the case of each slide are counted and the average number ingested by each leukocyte is calculated. This number is termed the phagocytic index. The opsonic index is determined by dividing the average number of bacteria per leukocyte, which have been ingested in the experiment with the patient's serum, by the average number ingested when the normal blood stream is used. The resulting figure representing the ratio between the phagocytic power of the patient's and the normal serum, the normal serum being considered as the unit. An opsonic index, therefore, of 1.5 indicates that the effective phagocytic power or opsonic power of the patient's blood is one and a half times that of a normal individual. If the result of the division is 0.5, it shows that the effective phagocytic or opsonic power of the patient's serum is just half that of the normal individual. In order to obtain an average normal serum, it is the custom to mix the blood serum of several individuals who are known not to be infected with the particular organism in question."

Wright states that when the opsonic power is elevated above the normal, it is indicative of a favorable response of the immunizing mechanism.

We may conclude that the organism can adapt itself to poisonous influences of different kinds, according to their chemical nature. We find that particular cells or groups of cells harbor this mechanism of adaptation. Such cells have the ability, when stimulated by poisonous stimuli, to produce bodies that are carried by the blood stream, enabling them to destroy such stimuli if they are of a bacterial nature.

Method for Preparing Bacterial Vaccines.—When preparing vaccines, infected material must be procured from suitable subjects. Pure cultures must be made of the bacteria that are producing the disease. The cultures must be suspended in a saline solution or oil and a preservative is added before placing the prepared vaccine in suitable containers.

In procuring infected material contamination must be avoided. Every care must be exercised to procure material that is apparently causing the disease. When possible material for making vaccines should be obtained from closed cavities. If pus from an abscess cavity is to be used, touching the surrounding skin must be avoided, the material should be only from pus contained in the abscess and not from the surrounding skin and other structures. We wish to obtain only the bacteria that are responsible for the suppuration. We wish to secure the Staphylococcus aureus or citreus and not the Staphylococcus epidermidis albus. Therefore, we should prepare the surrounding skin as for any other operation with Harrington solution or tincture of iodine. If the material is to be secured from the nose, the nasal cavities should be carefully prepared as if for an operation. The secretions to be used for the vaccine may be procured by rubbing a sterile cotton swab on the undersurface of the turbinated bones and septum. If from the ear, the auditory canal should be free of all excess secretions, the pus from which the culture is to be made should be taken with a sterile cotton swab from the infected areas. If we wish to secure cultures from infected lung tissues where there is no sputum or where it is clear that the sputum has no direct connection with the diseased areas, a sterilized glass syringe with a long needle may be used to obtain the desired substance. The skin, over the infected area, is carefully disinfected as for any surgical procedure. A puncture with the needle is made into the infected pulmonary tissue. Some authors recommend that the syringe should contain peptone broth, and after the needle has reached a desired depth, 1 c.c. of the broth should be injected into the lung structures and after a lapse of a few seconds, it should be drawn back into the syringe. This aspirated material is then to be used to make the vaccine. The usual method of collecting *sputum* does not always lead to satisfactory results. The ordinary expectorations are mixed with microörganisms from the buccal cavity, teeth, tonsils and postnasal spaces. To obtain the best results, the teeth should be brushed with a sterile brush, the mouth and throat washed with sterile water several times. Water should be swallowed to clean the pharynx. Then the sputum is to be expectorated into a wide-mouthed sterile bottle.

When collecting urine, the most satisfactory results are obtained by catheterization with a sterile catheter after the meatus has been carefully cleansed.

Blood is best obtained from a conspicuous vein at the bend of the elbow. After the skin has been carefully sterilized, a quantity may be withdrawn with a sterile syringe.

Making Pure Cultures.—By this is meant a technic that will enable one to secure the one or more varieties of organisms that cause a certain process. To separate the chief offenders from other microörganisms is often a most difficult task but, if we desire a certain effect, it is necessary, that the specific organisms be procured that will produce the desired antibodies. No one method can be followed for all varieties of bacteria. Briefly, the following methods have proved to be practical.

The nature of the infection may sometimes be found in stained smears of the secretions of the disease. Often an isolation of the specific germ may be effected by making plate cultures on solid media. Primary cultures may be developed. The pus from newly incised abscesses, or microörganisms in the urine or urethral discharges or secretions from the throat in influenza or sputum in pneumonia, may exhibit the characteristic microörganisms. The best culture media are those that contain blood serum.

Solid media are best suited for the preparation of vaccines.

Slant agar tubes are frequently used in making bacterial vaccines. Two tubes may be used for rapidly growing bacteria and six or more are used for more slowly growing organisms such as pneumococci and streptococci.

Shorter or longer periods are necessary to grow cultures; the time depends on the special organism. Usually twenty-four hours in an oven at a temperature at 37° C. and less time for those that grow more rapidly.

When cultures have been developed in the incubator, specimens from each colony are stained and examined in order to find the organism that causes the infection.

It has been the practice to employ an attenuated culture where the original organism is virulent. A second strain has been found to be safe in cases of certain streptococci and of pneumococci, etc.

When the cultures have become fully developed, the next step is to make an emulsion. This must be done with aseptic care. Take a test-tube of sterile normal salt solution and pour it on the surface of the slant tube containing the culture, then shake the tube so as to cause the microörganisms to become suspended. If the culture adheres to the medium, it may be separated with the aid of a platinum loop. The loop must be used with care so as to remove only the bacteria from the medium. The emulsion thus formed is poured on the surface of the second culture causing the latter to be suspended and add more salt solution if indicated. The entire series of cultures are suspended in the same way. The last suspension is then poured into a heavy flask containing glass beads. This flask is then shaken by hand or a mechanical shaker until the bacterial contents have been disintegrated and the emulsion has become thoroughly homogeneous. In order to be certain that the emulsion contains no large particles, it should be centrifugalized or filtered through a sterile filter. Culture media that contain peptone may develop toxic bodies that sometimes produce anaphylaxis. "In addition, when, in the preparation of a vaccine, bacteria grown on a serum medium are washed off with normal salt solution, a portion of the serum may be removed and in this way be capable of producing disagreeable local and general reactions. For these reasons it is advisable to wash all suspensions by repeated centrifugalizations until the supernatant fluid reacts negatively to the biuret or ninhydrin reaction." (Willard Stone, Kolmer.)

Standardization and counting of bacteria in suspension in a given quantity of fluid is done by several methods and while it might be of interest to describe several procedures, it will suffice for our purpose to detail only one, viz., that of Wright as described by Kolmer.

"**Method of Wright.**—Prepare a simple capillary pipette, making a mark on its stem about one inch from its tip, and fit a rubber teat to its barrel. Cleanse and prick the finger, press out a drop of blood, take up the pipette and draw up into it first one volume of sodium citrate solution, one of blood and then one volume of bacterial suspension or two or more volumes, if it appears on inspection to contain much fewer than 500,000,000 of bacteria to the cubic centimeter. To guard against crimping of the corpuscles in drying the film, Wright advocates aspirating one or two volumes of distilled water after the blood and bacterial suspension.

Now expel from the pipette first only the distilled water and the bacterial emulsion, and mix these, so that there may be no danger of the red corpuscles becoming hemolized and then proceed to mix together the whole contents of the pipette, aspirating and re-expelling these a dozen times. Then make two or three microscopic films from the mixture spreading these out on slides that have been roughened with emery.

The films are dried in the air, fixed by immersing them for two minutes in a saturated solution of corrosive sublimate, washed thoroughly and stained for a minute with carbolfuchsin diluted 1 : 10 or carbolthionin for two to five minutes and then washed and dried.

The films are now given a preliminary examination. If red corpuscles and bacteria are found in approximately the same numbers and the suspension is free from bacterial aggregates, the count may be made. If either of the bacteria or the corpuscles are largely in excess, new mixtures and new films must be made. In case the bacteria are gathered in clumps, the suspension should be shaken again and new film prepared.

When satisfactory films have been obtained, the actual counting may be done. This is carried out with an oil-immersion lens, and in order to secure accuracy, it is necessary to restrict or divide the field by a small square diaphragm made of paper or cardboard, or by inscribing lines on a small clean cover-glass and dropping them on a diaphragm of the eye-piece.

The field is now chosen at random, and the corpuscles and bacteria are counted, the results being jotted down on a sheet of paper. Proceed at random from field to field, traversing every part of the slide.

Establish a rule for counting corpuscles that transgress or touch the edge of the field. Eliminate from consideration any parts of the film in which the preparation is unsatisfactory as regards staining or with respect to the integrity of the red corpuscles. The examination is continued until at least 500 corpuscles have been counted, half of the count being made from the second slide. The number of micro-organisms is now totalled, and the approximate number per cubic centimeter estimated. Let us assume, for example, that 600 red cells and 1200 bacteria have been counted. A cubic millimeter of blood contains 5,500,000 red corpuscles, and equal volumes of blood and emulsion were taken. A cubic millimeter of the emulsion, therefore, contained $\frac{5,500,000 \times 1200}{600}$ = 11,000,000 organisms per cubic millimeter or 11,000,000,000 per cubic centimeter."

Vaccines are sterilized and their sterility tested after the preliminary examination. Heat is the usual agent employed, germicides are likewise used. When the films for counting are satisfactory, the vaccine is transferred to a test-tube. The latter is sealed and placed in a water-bath, care being taken that the whole tube is immersed. In the process of sterilization, pains must be taken to employ the lowest possible temperature and the shortest possible time to produce sterility. The usual temperature is between 50° and 60° C., if no more than an hour to complete the process.

Cultures should then be made of the vaccine to ascertain its sterile condition. A dozen or more loopfuls are then placed on slant culture mediums of blood serum or blood agar. The tubes are then placed in a culture oven for twenty-four or more hours, the time depending on whether the organisms are rapid or slow-growing ones. If the following examination indicates sterility, the vaccine is finished. If not sterile, more heat must be applied or a new one is made.

If the vaccine is found to be satisfactory, it must be diluted with a sterile saline solution so that each centimeter contains a definite number of organisms. A portion of the prepared vaccine is diluted and the remainder is saved in case the dose is to be modified in the subsequent treatment of the cases. If a vaccine of Staphylococcus aureus contains 1,500,000,000 organisms per cubic centimeter and the dose decided upon is 500,000,000 per cubic centimeter, sufficient vaccine for thirty doses is prepared by withdrawing 10 c.c. of vaccine in a sterile container and adding 20 c.c. of sterile salt solution. The mixture is agitated to insure thorough mixing, and 0.1 c.c. of a 1 : 100 dilution of phenol is added to each cubic centimeter of vaccine as a preservative. (Kolmer.) The vaccine should be kept in a sterile bottle, closed with a rubber cap. When a dose is to be given, the rubber cap is painted with tincture of iodine. The needle is thrust through the rubber and the desired amount is drawn out with an aseptic syringe. Flexible collodion is applied over the needle puncture. Frequently vaccines are placed in ampoules, each one containing a single dose. These ampoules must be sealed by heat.

Sensitized Bacterial Vaccines.—Sensitized bacterial vaccines are prepared by first immunizing a rabbit with subcutaneous injections of microörganisms which have been killed by heat. Increasing doses are given until the animal withstands living organisms intravenously. The animal is then bled and the serum is mixed equal parts with emulsions of bacteria. After being thoroughly mixed and centrifugalized, washed and tested for sterility, counted and suspended in normal salt solution, the sensitized vaccine is ready for use.

Method of Administration.—An all-glass sterile syringe is used to administer bacterial vaccines. The syringe should have a sharp platinum-iridium needle. Vaccines are best given in the early part of the day because they are often followed by depression and ill feeling. These symptoms pass away in a few hours and will have disappeared by night so that the patient will have a better night's rest. Injections are best given in loose areolar tissues and at such points where there is a minimum amount of muscular movement and where the clothing causes the least discomfort.

The points of election are below the clavicle, upper margin of the buttocks, along the McBurney line. The skin is first disinfected with soap and water or tincture of iodine. The skin, at the point of injection, is raised between the thumb and finger and the needle is then thrust into the subcutaneous tissues between the raised layers of skin.

In the greater number of cases, there is a local irritation of the skin at the point of injection.

The site of the injections sometimes shows a decided reaction after an inoculation, this is known as a focal effect. Such a reaction, as shown by increased redness, may serve as a guide for further dosage. A decided reaction indicates decreased dosage. The general systemic effects vary greatly in different subjects. An indicated dose usually produces more or less exhaustion, fever, headache and accelerated pulse-rate.

We are still undecided in reference to frequency and exact dosage. Each case must be judged by itself. Since the opsonic index has been found impracticable in general practice, we must depend on the reaction of the patient to each dose and the general condition for which he is treated. It can be easily understood that in very acute infections, particularly when occurring in weakened persons, a small and safe dose is indicated. All therapeutic vaccines should be used, in their initial dose, in minimum amounts. Begin with a safe dose and, if there is no reaction in forty-eight hours, a larger one may be given. Should local or general symptoms follow the first inoculation, a second one of the same size may be administered in four to six days. It must be borne in mind that fresh infections by other organisms may occur, and if it does, new vaccines should be made, in order that the antibodies for the new invaders may be included.

Sometimes there is a decided and severe reaction after the initial dose which would indicate that a *negative phase* had been induced which is a period of lowered opsonic power, of lowered resistance, in fact, the use of too large doses of vaccines, is manifested at once by local changes, which show that the process is increasing. On the other hand, if there is an amelioration of the general symptoms, we have a period of increased resistance, of elevated opsonic power, known as the *positive phase*.

It is often difficult to decide the intervals between the inoculations. The tendency is to repeat them with too great frequency. The better plan is to underdo than overdo.

The dose of the vaccine varies somewhat in the kind of organisms involved in the infection and also whether the process is acute or chronic. In acute cases the dose is smaller and given oftener and in chronic cases it is large and in longer intervals. The age and weight of the patient are also determining factors. When in doubt begin with small doses and increase or diminish according to the local and general reaction. Repetition of doses depend upon the reaction and the results obtained.

The following list is offered as a suggestion as to dosage for vaccines.

Staphylococcus aureus	100,000,000 to 1,000,000,000
Staphylococcus albus and citreus	200,000,000 to 1,000,000,000
Streptococcus pyogenes	25,000,000 to 200,000,000
Gonococcus	25,000,000 to 200,000,000
Typhoid bacillus	250,000,000 to 1,000,000,000
Colon bacillus	100,000,000 to 1,000,000,000

Under the following heads several infectious conditions usually known as surgical infections have been briefly considered, and their treatment with bacterial vaccines have been indicated.

The vaccine treatment of tuberculosis has been omitted for the reason that the effects of heliotherapy and an atmosphere comparatively free from pathogenic microörganisms, general hygienic surroundings, and diet have shown increasingly brilliant results, both in surgical as well as in pulmonary tuberculosis. Vaccines, both bacterial and non-bacterial, have not fulfilled our optimistic expectations, especially in tuberculous affections. In the light of our present knowledge of their effects they can only play a subsidiary role.

SEPTICEMIA.

In septicemia we give vaccines subcutaneously to produce a reaction followed by an increased immunity. But before proceeding with the use of vaccines we must determine whether we have to do with bacteria that originate in an active focus of infection, such as a deep-seated abscess or that form in which the bacteria appear to be growing in the blood stream. If the infection originates in a definite focus, there is a constant addition of bacteria to the blood stream, and we may speak of continuous auto-inoculation. We must place under this head acute fulminating infections and also carbuncle, phlegmon, erysipelas and others. The other class comprises infections whose source is clinically not demonstrable and where the point of infection cannot be removed or drained. These are the true septicemias. It is clear that before the treatment of septicemia is begun, the locus of infection when found must be attacked and eradicated or drained or both. We cannot hope for success if this is not done.

Diagnosis.—It is important to make a bacteriological diagnosis when possible. It is desirable to determine whether our septicemia is due to a streptococcus, staphylococcus or other organisms. Having found the pathogenic micrococci the usual technic well known to all laboratory workers must be employed with the view of preparing an autogenous vaccine. Agar, as a medium, for blood cultures of a pneumococcus, the most common factor in septicemia, has been successfully used by Rosenow. Both solid and liquid media have given satisfactory results. The methods for their preparations have been indicated in the preceding pages.

Prognosis.—That the prognosis is different in these two types of septicemia is evident. When we can eliminate by early operation the source of auto-inoculation, the chances for recovery are good. In the true septicemias the point of auto-inoculation is beyond our control. The blood current appears to be a favorable medium for bacterial growth. The prognosis is correspondingly grave.

Dose.—When possible be guided by the opsonic index, but septicemia may be successfully treated by taking into account the clinical manifestations. We must guard against overdosage on account of the danger of overstimulation which may be inimical to the protective mechanism. Therefore, prudence would dictate that the initial dose be small. In streptococcic septicemia, the primary dose should not be over 1,000,000 to 2,000,000 and be repeated in twelve to twenty-four hours if no unpleasant symptoms develop. The increase in dosage depends on the resulting reaction. If no untoward conditions appear, the dose may be increased from day to day until the maximum of 25,000,000 daily has been reached. As improvement takes place, it may be well to repeat the dose every second day and even longer. We must not always be guided by the number of bacteria contained in a given dose but rather by the effect that each dose produces. A good rule to follow is, the more ill the patient, the smaller the initial dose. If, in the course of the treatment, there is a sudden aggravation of toxic symptoms as is shown by a rise in temperature and increased prostration, the next dose must be smaller and the interval between the doses should be increased.

SUPPURATIVE ARTHRITIS.

In these conditions the microörganisms found are the staphylococcus, streptococcus and pneumococcus. As soon as the condition is recognized, we must attack the local condition either by the injections of solution of formaldehyde according to Murphy, or by the establishment of thorough drainage. If this is not done promptly, the function of the joint is endangered no matter how carefully the vaccine therapy has been employed. The details of the surgical management need not be discussed here but it is of first importance.

If, in spite of thorough surgical measures, the infection does not subside, and we can find no other locus of infection or if the septicemia becomes chronic, an appropriate autogenous or stock vaccine may be employed. The dose should be small and their size and frequency regulated according to the effects on the local and general conditions.

GONORRHEAL ARTHRITIS.

The majority of the cases of this type of infection when acute subside by immobilization and rest in bed. In the initial stage of this infection, we have a more or less auto-inoculation but it soon becomes localized. Vaccines are usually not indicated in the acute stage, but they have been used with success. When the case becomes chronic, a vaccine may become a stimulus and incite the protective mechanism. Many observers testify to the efficiency of gonococcus vaccines and speak highly of their use. Hartwell[1] tabulated 31 cases. He treated these cases for periods varying from one month to one year. He described 27 cases as having completely functionating joints. The others had ankylosed joint of varying degrees when the treatment began. He gave doses as high as 600,000,000 at intervals of five days to a week. In 21 cases he employed autovaccines which he believed more effective than stock vaccines. He states that the pain was diminished in 20 acute cases and hastened recovery. In some of his acute cases other joints became affected which is not uncommon in the ordinary course of the disease. He gave doses of from 25,000,000 to 100,000,000 in from two to four days.

Hartwell believes gonococcal vaccine is useful in gonorrheal arthritis in all stages except in cases of ankylosis. It does not prevent metastases to other joints.

The consensus of opinion by the majority of observers is that gonorrheal vaccines are more effective in chronic than acute cases.

RHEUMATIC ARTHRITIS.

Many cases of chronic articular rheumatism have recently been regarded as being of bacterial origin, although no specific organism has been found. These joint affections present local inflammatory symptoms. They sometimes follow the development of pyorrhea, rhinitis and especially tonsillitis. They appear after scarlet fever. Undoubtedly bacteria, that have found their way into the blood stream, localize themselves in the joints. Streptococci are often obtained from the blood by means of cultures. We know that we have postscarlatinal kidney infections showing streptococci. Likewise can the same organism be demonstrated in scarlatinal arthritis. The same form of bacteria can be cultured from secretions found in all

[1] Ann. Surg., November, 1909.

joints that come to suppuration. Streptococci once having gained access to the blood current find points of predilection, such as occur in a retarded circulation, and almost stagnant lymph fluid near joints. The blood seems to have been greatly deprived of its germicide power, the bacteria find favorable conditions for their propagation in their new locus. The opsonic index, at these points of infection, is subnormal. When these arthritic infections become chronic, the opsonic properties of the blood stream becomes low. The circulation is more or less retarded and almost stagnant, consequently the diminished amount of opsonins coming in contact with the microörganisms is not sufficient to insure their destruction. It would seem that this theory is confirmed by the relief afforded after the use of the constricting band used in Bier's method where we find that fresh blood with normal or increased amount of opsonins as well as fresh leukocytes are driven into the infected area, and later driven into the general circulation and lymph channels. The stagnant blood and lymph has been replaced by fresh blood and lymph including new antibodies.

Bier's method has recorded many clinical successes and deserves a more extended trial than it has generally received. It has the advantage that a bacterial diagnosis is not necessary.

Diagnosis.—A local bacteriological diagnosis is often very difficult and, in most instances, impossible. We must bear in mind that many cases of "rheumatic" and other forms of arthritis have been preceded, and seem to have had their origin in an attack of tonsillitis, laryngitis, pharyngitis or rhinitis and pyorrhea. It has, therefore, been advised that cultures be made from the nasopharynx or nasal cavities and the pus from the alveolar margins and, if, for instance, a culture of pneumococcus be obtained from the tonsil, an autogenous vaccine be made and administered.

Before giving vaccines local infections must be attended to. Tonsils and teeth should first be removed if they appear to be infected.

Dosage.—If there is an increased temperature, the dose would be from 5,000,000 to 25,000,000. In non-febrile cases small doses at intervals of one to two days are given according to the reaction. In chronic cases large doses may be used at intervals from three days to a week.

If vaccines are of any value, it would seem that an increasing experience, theoretically at least, would promise encouraging result in chronic non-suppurative or peri-arthritis, providing our technic of making a bacteriological diagnosis can be perfected. There is danger of overdosage.

FURUNCLE.

In a case where the infection begins in a hair follicle as indicated by a tender, red, painful induration, its treatment depends on the stage and location in which it is found. If a pustule, it should be opened by a puncture and disinfected and dressed with a hot moist antiseptic dressing. If there is no evidence of suppuration, one dose of

Staphylococcus pyogenes aureus of stock vaccine may abort it. A repetition once or twice at intervals of two or three days may be necessary. In two or three days the infected area will begin to slough.

Furunculosis is a condition where there is a repetition of furuncles. In some cases there is a tendency to furuncle formation. We sometimes find individuals with an oily pale skin that frequently develop many furuncles over a long period of time. They seem to have a predilection to harbor pyogenic cocci. In some cases the individual may inoculate himself in new localities by scratching often during his sleeping hours. He scratches the primary furuncles, infectious material is caught under the finger nails and transplanted to other parts of the body. One furuncle is incised when others develop. In one of the author's cases a full year passed before the furuncular process came to an end. More than one hundred furuncles were incised. A urinalysis must not be neglected, especially in reference to the existence of glycosuria. It is in this field that many excellent results have been reported. It is here where an accurate bacteriological diagnosis can be made. The pus can be easily obtained and cultured and should be used when practicable. In these cases stock vaccines seem to have been useful. The vaccines are composed of three or four virulent strains of Staphylococcus aureus. However, when possible, autovaccines should replace stock vaccines as soon as they can be made. The initial dose should be 100,000,000 to 150,000,000 and should be repeated every third day. The dose may be gradually increased to 300,000,000.

If in twenty-four hours the furuncle appears larger and more painful and if one or two new ones develop, the dose should be smaller because we have to deal with a negative phase. If in one or two days there is improvement and the general symptoms are improved, the correct dose has been found and we have a positive phase. New furuncles may continue to develop for a time but they are less severe and the intervals become longer and they disappear more quickly.

If the case is chronic, and especially if there are present many comedones and the pustules are on the back and neck, the treatment may require two or three months of time.

Recurrences are not uncommon and must be guarded against by advising the patient to return for fresh inoculations as soon as the first evidence of return is manifest. The final outcome is favorable if the treatment is persisted in. Since the opsonic index has been found impractical we are obliged to regulate dose and interval by clinical observations.

In the treatment of these cases, we may feel uncertain as to the interval between doses and their exact size, therefore we must be guided by the manner in which the patient responds. Many writers of large experience, advise intervals of three days. We should try to measure the dose so as to insure a short period of negative phase—with its lowered resistance—so as to produce as long a period of positive phase—a period of increased resistance. Each patient is a law unto himself. A safe rule is to employ a small dose which insures a short duration of the negative phase, which makes a short positive phase. But as we learn the tolerance of the cases, the dose can be increased and repeated in from one to six days.

CARBUNCLE.

There are those who have grown enthusiastic over the use of vaccines in the treatment of carbuncle. They feel certain that in almost every case the process is modified so that surgical intervention becomes simplified and can very often be avoided. Our experience has taught us that radical interference, that is, total extirpation of the carbuncle, is usually efficient and leads to prompt recovery. We have found no reason why prompt operation is still not the best method. It cannot be denied that bacteria and their products have found their way into the blood stream. There is a constant auto-inoculation. In a furuncle the pus and necrotic material is usually confined to a single pocket which may be evacuated by a single puncture or incision. In carbuncle there is an extensive infiltration of the connective tissues with pus. In carbuncle there is apparently an absence of a line of demarcation, owing to the virulence of the pathogenic organisms and to the liquefying power of the pus which dissolves the fat and connective tissues as it extends. The circulation is everywhere cut off, so that the invading organisms are unaffected by the antibodies carried in the blood stream. The coagulated lymph and exudation prevent an access of blood. The process is essentially an infiltrating one, particularly when located on the back of the neck. The columnæ adipose separate the subcutaneous connective tissues into numerous cells composed of connective-tissue walls. In cases like this it would be unreasonable to do anything but radical surgical interference and this is true of all carbuncles wherever located. After free excision, a culture should be made of the pus to prepare an autogenous vaccine for the purpose of antagonizing the infectious substance floating in the circulation. The operative procedure often causes an exacerbation of the temperature due to auto-inoculation. A moist antiseptic dressing, frequently changed, must be applied. A free discharge from the wound takes place owing to an increased blood supply to the wound. After the effects following the surgical intervention have subsided, the injection of the vaccine may be done. A small dose of vaccine not exceeding 100,000,000 may be employed which may be repeated two days later and then every three to four days if the temperature continues to fall. Should there still be an elevated temperature after the third day, especially if there is no drop, a smaller dose of 50,000,000 should be used and repeated daily until we have a normal temperature and then 100,000,000 every second day, and at longer intervals until recovery is complete. The wound must be dressed daily.

The urine must always be examined especially for sugar. If the latter is present, the opsonic index is always lowered. The usual dietetic restrictions for glycosuria must be observed.

When the carbuncle is on the face the excision should be short with due regard to the resulting scar. Only the necrotic tissue should be excised. Since carbuncles in this region are usually not large and the auto-intoxication relatively less, the initial inoculation need not exceed 25,000,000 Staphylococcus aureus and increased as conditions seem to indicate. Any new pustules are to be punctured and any necrotic margins are to be excised with scissors. In five to six days the wound is usually clear and granulating.

EMPYEMA.

This condition is usually due to the pneumococcus and streptococcus. Usually a free opening and efficient tubular drainage is quite sufficient for recovery without the aid of other immunizing agents. There are a few cases where, in spite of thorough drainage, an elevated temperature persists which may be due to defective immunizing power; bacterial vaccines are indicated. In such cases doses of pneumococcus of from 10,000,000 to 100,000,000 may be given. The more profound the intoxication, the smaller the dose. The dose is to be repeated every twenty-four hours if it is small and at longer intervals if it is larger.

OSTEOMYELITIS.

The administration of vaccines should always be preceded by operative interference and complete and free evacuation of the pathological products. Free drainage is of prime importance. In some cases an infection of the soft parts continues as is indicated by a persistence of local and systemic manifestation such as swelling pain and increased temperature. Vaccines may be indicated in these cases, in doses ranging from 100,000,000 to 300,000,000 every three to five days. Usually, however, all systemic manifestations disappear when the infectious material has a free exit and when the improvement is prompt, as it usually is, vaccines are superfluous.

ERYSIPELAS.

The most common seat of erysipelas as met with in general practice, is in the face. These attacks are usually self-limited and are of such short duration that vaccines are not indicated. It is only in the spreading type in which we may expect some assistance from vaccines. Autogenous vaccines should be used when they can be obtained, but the more common practice has been the use of stock vaccines. During the active stage small doses are indicated. We must regulate our dosage as in septicemia. The initial dose should not be over 1,000,000 once daily and increased slowly not to exceed 25,000,000. The usual local treatment must not be neglected. Observations thus far have not enabled us to speak with certainty as to the actual benefits derived from the use of vaccines in erysipelas, but their use must not be entirely ignored.

VARICOSE ULCERS.

Staphylococci are often found in these ulcers. It has been claimed that autogenous vaccines of these organisms are useful in leg ulcers. It is asserted that the use of stock vaccines has cleared up the ulcer in a few days. The wound was dressed daily with Wright solution consisting of 0.5 per cent. of citrate sodium and 2 per cent. of sodium chloride. However, vaccines must be looked upon as only an adjunct to other measures which are indicated. We must take into account and treat the venous varicosities which exist in most cases, nor must we neglect antiseptic and aseptic precautions so essential in the treatment of all wounds.

BLOOD TRANSFUSION.

NELSON MORTIMER PERCY, M.D., F.A.C.S.

WHILE the transfusion of blood as a practical procedure is a comparatively new acquisition in the field of surgery, the idea of using blood as a therapeutic measure dates back to the fifteenth century. In 1660, Lower[1] in his experiments made successful transfusions in various animals. Following this, the blood of animals, usually from sheep, was given to humans with apparent benefit in an occasional instance. It soon became evident that the introduction of the blood of lower animals into man was an unsatisfactory and dangerous procedure and the practice fell into disuse. It is probable that many of the deaths were due to hemolysis or anaphylaxis.

Animal transfusion was then abandoned for human transfusion, and during the past century many experiments were made on the direct transfusion of blood from one person to another. Transfusion of human blood, as practised during this period, was so unsatisfactory and dangerous that this procedure also fell into great disfavor.

The failure of these early transfusions was probably due to two main factors: that the attempt was made before the days of aseptic technic; and because of the lack of knowledge of the incompatibility of various bloods with each other. In 1870, Landois[2] opened the way for the safe transfusion of blood when he discovered that the blood of one individual was not always compatible with that of another. While he did not explain this phenomenon, nor offer any method of determining the incompatibilities of various bloods, he showed that the serum of one animal might dissolve the red corpuscles of another.

It remained for Moss[3] to publish in 1910 his studies of iso-agglutinins and isohemolysins. He showed that the blood from two individuals may not mix well because of the fact that the red corpuscles of one or of each may be agglutinated by the serum of the other, and that the corpuscles agglutinated in this way may be hemolyzed as well. He further showed that all individuals soon after birth may be grouped into four distinct classes, depending upon the ability of their serum to agglutinate the red corpuscles of members of the other groups, and on the susceptibility of their corpuscles being agglutinated by the serum of members of other groups. The principles established by Moss really opened the way to the practical work of using blood as a therapeutic measure in patients suffering from various conditions.

[1] Philosophical Transactions and Collections of Medical and Philological Papers, John Lawthrop, 1731.

[2] Die Transfusion des Blutes, 1875.

[3] Bull. Johns Hopkins Hosp., March, 1910.

Recently, because of the increased interest in the possibilities of transfusion, many methods of transfusing the blood have been devised, making transfusion practical. With the development of these various methods, the various factors responsible for the untoward symptoms following transfusion have been eliminated, and as a result, transfusion of blood in the hands of an experienced operator can be done with very little or no danger to either the donor or recipient of the blood.

Indications for Blood Transfusion.—Blood transfusion is used as a surgical therapeutic measure whenever all or part of the elements of blood tissue are needed and cannot be obtained in sufficient amounts from the hematopoietic organs of the individual. These elements may be required: (*a*) To replace loss of whole blood, (*b*) to increase coagulability, and (*c*) to stimulate resistance to infection and various other toxic processes.

It is a well-known fact that the administration of normal salt solution or the various modifications of Ringer's solution, either intravenously or subcutaneously, has a marked beneficial effect in certain conditions where more fluid is needed that cannot be ingested by any other means. By this form of treatment, then, one can hope only to give an increased amount of body fluid. On the other hand, by the transfusion of whole blood, one injects a living tissue which has functions inherent on its own constituents, and which thereby serves an entirely different purpose.

When this treatment was first exploited it was used, as is usually the case, in many conditions in which it had no effect, or even did harm. At present, however, we know that in many instances the addition of fresh, living, whole blood to a patient from another individual may save a life, cure the pathological condition present, or at least, greatly improve the patient.

The indications which, from our experience, are those best suited to this form of treatment will now be given in more detail.

Hemorrhage.—Severe hemorrhage is, of course, a specific indication for blood transfusion, and it is in these cases that the most brilliant results have been experienced. In postoperative, postpartum, and gastric ulcer bleeding this method has been advocated and used with success for a number of years. However, one should bear in mind the fact that Nature attempts to control the hemorrhage in two ways: (*a*) by producing a fall in blood-pressure and, (*b*) by attempting to cause a clot at the end of the bleeding vessel. If additional blood be added in sufficient quantity to increase the blood-pressure momentarily a clot may in this way be dislodged and the hemorrhage increased. Where it is possible to check the hemorrhage by mechanical means, such as by open operation in gastric ulcer or in ectopic gestation, or by packing in postpartum bleeding, blood transfusion, both before and after such procedure, tides the patient over an otherwise frequently fatal period. It is in the severe hemorrhages that large amounts, from 600 c.c. to 1500 c.c., are given. The transfusion of amounts less than 600 c.c. has not, in our experience, been sufficient to control such cases.

We have also noted that amounts greater than 900 or 1000 c.c. do not produce more satisfactory effects than the giving of 600 to 800 c.c., and repeating one or more times. This amount seems to be best suited both to replace the lost blood and to favor clotting at the bleeding point.

Obscure Hemorrhages.—Occasionally one encounters a patient in whom, following a surgical operation, without any apparent cause a secondary hemorrhage occurs from the wound after a period of from one to three weeks, and will keep recurring in spite of all the ordinary medicinal and surgical means at one's command. Many of these cases in the past have terminated fatally. These cases usually do not give a history of hemophilia, and, so far as I know, no reasonable explaniation as to the cause has ever been given.

Illustrative Case.—A woman, aged forty-eight years, in apparent good health, except for usual symptoms from a lacerated perineum. The patient was taken to the hospital and a perineorrhaphy performed. A good immediate recovery followed and the patient returned home at the end of two weeks. A few days later, which was eighteen days after the operation, a severe hemorrhage occurred from the perineum. The hemorrhage was finally controlled by enlarging the opening in the perineum from which the blood was coming and packing the area with gauze. Three days later, when the packing was removed, a lively hemorrhage followed immediately. Packing was replaced and as soon as could be arranged the perineum was reopened and sutured. At this time the patient was given some coagulose. One week later the hemorrhage recurred. The perineum was again partially opened and packed with gauze. During the following two weeks the packing was changed every three or four days and each time active hemorrhage occurred. During this period coagulose was used and also several doses of horse serum. Calcium chloride was also given and the patient placed on a gelatin, white of egg and milk diet. I saw the patient seven weeks after the operation, at which time she had a pulse of 140, was extremely weak; had no appetite; temperature subnormal; hemoglobin 20 per cent.; red count 1,200,000; white count 8000. A donor was immediately selected and the patient was taken to the operating room. Upon removing the perineal packing a marked bleeding occurred, the blood being very watery like. The principal part of the bleeding was controlled by suturing the perineum, but in spite of the fact that round, non-cutting needles were used, slight bleeding came from around each suture and it was impossible to control the oozing. As soon as the perineal wound was rendered as dry as possible a transfusion of 900 c.c. of blood was given. Within ten minutes from this time the perineal wound was perfectly dry and the pulse had dropped from 150 to 110. Five days later a second transfusion of 700 c.c. was given. There was absolutely no bleeding from the time of the first transfusion, the wound healed primarily, the patient made a rapid convalescence and left the hospital at the end of three weeks, with a red count of over 4,000,000, and has remained in good health. No doubt this case would have terminated fatally, in spite of anything that could have been done, had not the blood transfusion been given.

Hemorrhages Complicating Infectious Diseases.—Troublesome hemorrhanges occurring as a complication of one of the infectious diseases can usually be relieved by blood transfusion.

Illustrative Case.—A boy, aged seven years, with apparent good health, developed rather typical signs and symptoms of measles, except that the accompanying rash disappeared in about twenty-four hours. One week later he began to bleed from mouth, stomach and bowels. Blood was also present in the urine. The bleeding persisted and at the end of the second week numerous purpuric areas appeared on the skin. At this time his condition was grave; pulse, 160 per minute, weak; hemoglobin, 15 per cent.; red count, 1,200,000; hemorrhages persisting. Transfusion of 600 c.c. of blood gave instant relief. The hemorrhage ceased within five minutes and the patient made a rapid and complete recovery.

Typhoid Fever—Early in transfusion work, hemorrhage complicating typhoid fever was not considered as a condition in which blood transfusion was indicated. Recently, however, a number of typhoid cases complicated with hemorrhage have been transfused, in which the hemorrhage stopped immediately after transfusion of whole blood, following which the patients went on to complete recovery.

Icterus.—Patients with obstruction of the common duct with longstanding jaundice are extremely hazardous surgical risks. These patients usually do well for a couple of days following an operation, then have some hemorrhage from the wound, not severe, however, and then gradually weaken and just slip away without any special symptoms and without any apparent cause. Blood transfusion is indicated in these cases if a surgical operation is performed and will often tide the patient over an otherwise hopeless period. During the past two years the author has systematically transfused all cases of marked persistent icterus at the time of the operation, none of which has died from cholemia, while from past experience it is evident some of these cases would have terminated fatally without the transfusion.

Anemia Complicating Pregnancy.—Occasionally one encounters a rare type of anemia occurring as a complication of gestation, which simulate very much a pernicious anemia. In most instances the anemia improves immediately following delivery without any special treatment. Occasionally the anemia continues to progress after delivery. In such instances blood transfusion is indicated and is followed by brilliant results.

Secondary Anemia.—In cases of persistent oozing of blood in small amounts from any part of the body, with a consequent secondary drop in the blood picture or in which there is a constant destruction of circulatory elements from an infective or toxic process, blood transfusion has been found of great value. Amounts of 500 to 700 c.c., repeated at every six to ten days, do as much good as when larger amounts are used. The transfusions should be repeated until the bood picture has permanently improved. Conditions included in this class are: intestinal bleeding, epistaxis, pulmonary hemorrhage, hemorrhoids, and hematuria from various causes.

Hemophilia.—In this condition there is a greatly delayed coagulation time, so that small abrasions may allow of severe and persistent hemorrhage. Frequently, the blood of these patients will fail to clot in an hour or more. Here, blood transfusion may be employed during the active stage of bleeding, because enough prothrombin will in this way be supplied to produce the necessary clotting. At the same time the lost blood is being replaced by new blood elements. For this reason whole blood is a better medium than blood serum alone. Even after the bleeding has stopped, it is advisable to give occasional prophylactic transfusions of 500 to 700 c.c. of whole blood in order to supply the demand for prothrombin.

Hemorrhagic Diseases of the Newborn.—In these conditions the treatment by blood transfusion has been successful in a large number of instances and the lives of many infants have been saved. There is, of course, great difficulty in using the veins of infants, and for this reason, Helmholz has recently carried out a method which has been used in many cases. He punctures the anterior fontanelle in the midline and so enters the superior longitudinal sinus, which is a relatively large vessel in infants.

Toxemia.—In toxemia from any cause, or where there is a condition of general debility due to disease or metabolic derangement, blood transfusion has proved of marked benefit.

Septicemia.—We have seen several cases of severe septicemia following pelvic cellulitis, postpartum infection and peritonitis in which the process had gone on to a practically hopeless stage and in which blood transfusion was resorted to as a last measure. Several of these cases were definitely improved and a few of them recovered. It would seem that in such instances the resistance of the patient was just insufficient to combat the disease. By the administration of whole blood, new antibodies and fresh red cells were furnished which became the added stimulus necessary to give the resisting process the upper hand. We therefore believe septicemia, bacteremia and toxemia to be favorable indications for blood transfusion.

Banti's Disease and Hemolytic Icterus.—These conditions are essentially surgical and blood transfusion is not indicated where the blood picture is not materially lowered. When, however, the red cell count is lower than 2,500,000 or there are persistent hemorrhages, blood transfusion should be resorted to as a preliminary treatment to splenectomy. The latter procedure offers the only hope of a permanent abatement, but the previous administration of new blood usually allows of a better surgical risk. In fact, blood transfusion has been shown by many different workers to be of benefit, at least temporarily, in practically every blood disease.

Acute Surgical Shock.—In cases in which it is known that a severe operation is necessary, such as in carcinoma of the intestine and in which there is a marked cachexia and general weakness, these cases can often be improved in a general way to such an extent that the danger of surgical shock is markedly decreased. One, two or three blood transfusions of 500 to 700 c.c., given a week apart before the operation, will sometimes make an otherwise hopeless condition a fairly good surgical risk. Likewise, after a long, tedious, severe operation, the administration of a pint of whole blood just after the operation is finished and while the last stitches are being applied will make a change that is often quite remarkable. A marked improvement of the general condition of the patient is evidenced by a better surface color, a strengthening of the heart action and a drop in the pulse rate of 30 to 50 beats per minute.

Illuminating Gas Poisoning.—In illuminating gas poisoning there is a permanent destruction of the hemoglobin in the red cells so far as the oxygen-carbondioxide carrying capacity is concerned. In such cases the transfusion of whole blood, thus adding enormous numbers of red cells and fresh hemoglobin, has in several instances saved the lives of individuals that would otherwise probably have gone on to a fatal termination.

Pernicious Anemia.—The transfusion of blood in pernicious anemia has recently received a great deal of attention and has been advocated by some as the sole means of treating this form of anemia.

In view of the fact that pernicious anemia is, in all probability, a disease of infectious origin and that the spleen has abnormal hemolytic action on the blood elements with a late bone-marrow exhaustion, the writer is convinced that the rational treatment consists of three main factors, viz.: (*a*) massive stepladder transfusions of whole blood, (*b*) splenectomy and (*c*) removal of all possible sources of infection.

Each of these steps plays an important part in the treatment. The repeated blood transfusions nourish and stimulate the bone-marrow to action and help to restore the secondary changes in the various organs; the splenectomy unquestionaby reduces the amount of blood destruction, and the removal of the various foci of infection will relieve the patient of a chronic toxemia and possibly of an etiological factor of the disease.

The employment of blood transfusion will result in marked temporary improvement in the vast majority of cases. Our experience has been that while the blood pictures will improve immediately in practically every case, and that in some early cases a prompt and marked remission will take place and may persist for a period of several months, on the other hand, in the late cases, the improvement in the blood picture from transfusion alone is very transitory, as the blood will begin to decline within a period of two or three weeks unless transfusion is repeated.

In all of our cases except two that have come to operation, transfusion has been used as a preliminary measure before operation. It has also been employed in several extreme cases simply as a measure of prolonging life for a short time. From our experience it would seem that practically every case of pernicious anemia, even those in an extreme condition, can be temporarily improved. Ottenberg and Liberman,[1] however, found that in 25 cases of pernicious anemia treated by blood transfusion only 14 showed, for a time, progressive improvement. In 11 cases transfusion was of no avail. From this they conclude that blood transfusion induces a remission in about one-half of the patients, and that if improvement does not follow the first transfusion, another donor should be selected and transfusion repeated.

During the past five years the reader has transfused ninety patients suffering from pernicious anemia, including sixty-six that have come to operation, and a marked improvement, both in the blood picture and clinical condition of the patient, has resulted in all but one case. This patient was brought to the hospital in a comatose condition, received one blood transfusion, with practically no change in condition, and death resulted ten days later.

The immediate effects of transfusion are usually quite striking. The red blood count is increased (often doubling immediately when the count is very low), the hemoglobin percentage rises and the number of platelets is increased. The blast cells usually become more numerous, and occasionally Howell's particles will appear in the blood, thus indicating a stimulation of the bone-marrow.

Robertson[2] studied 4 cases of primary pernicious anemia treated by blood transfusion, with a view of determining the effect of the treatment in the excessive output of urobilin. Three of the four patients gave evidence of a resulting bone-marrow stimulation and at the same time showed a temporary increase of urobilin excretion. In one instance there was no change in the output of urobilin.

After transfusion the patients immediately, as a rule, volunteer the information that they feel stimulated and much "stronger than they felt before." A few hours later they become ravenously hungry, while previously food often had to be forced upon them. This hunger and relish of their food persists even after the red blood count begins to fall, which usually takes place about ten days or two weeks later. With the improvement in appetite the mental symptoms grow better, the insomnia is relieved and the glossitis clears up. There is no doubt that the transfusion of large masses of whole blood accomplishes more than the mere mechanical addition of so much blood. It seems that it actually exerts either a curbing influence on the hyperactive spleen or a stimulating action on the bone-marrow, since the blood picture continues to improve for several days after transfusion. This may be due to the fact that the blood-forming organs are not only overworked, but are also undernourished. Furthermore, multiple blood transfusions supply protective antibodies and assist the patient in getting rid of the secondary changes which have taken place in the various organs. During the period when the individual is being prepared for operation by multiple blood transfusions, he should be treated to eradicate any

[1] Jour. Am. Med. Assn., 1915, lxiv, 2163.
[2] Arch. Int. Med., 1915, xvi. 429.

self-evident infection, such as infected teeth or tonsils, pyorrhea alveolaris, etc.

The patients begin to improve immediately after the first transfusion and continue to improve with each subsequent transfusion until they are good surgical risks, and splenectomy can be done without greater shock than would be produced in any other patient by an operation of the same magnitude. At the time of operation a transfusion of from 600 to 1000 c.c. of blood should be given immediately at the close of the operation.

By combining the blood transfusions with splenectomy and eradication of all foci of infection our results in pernicious anemia have been very encouraging.

Preliminary Examination.—The most important part of transfusion is the selection of a healthy donor, and the making of hemolytic and agglutination tests between the two bloods. In addition to this, it is well to determine as nearly as possible the exact condition of the blood before transfusion in both the donor and the recipient. This examination should consist of a red and white cell count, hemoglobin percentage, coagulation time, a differential count, also noting the character of the various types of corpuscles.

Donor.—In selecting a donor it is important, in addition to making hemolytic and agglutination tests, that a careful history be obtained from the donor, and a complete physical examination made, including a Wassermann test. Donors should not be chosen from persons giving a history of recent attacks of typhoid fever, pneumonia, diphtheria, tonsillitis, malaria or influenza, or from persons suffering from tuberculosis, chronic arthritis, rheumatism or where there is a history of hemophilia.

Hemolytic and Agglutination Tests.—A hemolytic or agglutination test of each blood upon the other should always be made before transfusion, because it has been found that in a considerable percentage of cases there is a tendency of the serum of one blood to cause a disintegration of the red cells of another even when the latter be a near relative. While the bloods from members of the same family are more liable to be compatible with each other than aliens' blood, still it is never safe to use even a close relative as a donor without making a hemolytic test between the bloods to be mixed.

Hemolysis Test.—Ten cubic centimeters of blood are collected from a vein of the donor (D.), 5 c.c. of which is placed in a dry centrifuge tube and allowed to clot and the remaining 5 c.c. mixed thoroughly with 10 c.c. of a 0.5 per cent. sodium citrate in normal salt solution. The latter solution preserves the red cells and prevents clotting. Both tubes are now rapidly centrifuged. In one tube the clotted blood will separate, leaving a clear serum as an upper layer; 1 c.c. of this serum is then added to 9 c.c. of normal salt solution in a test-tube and labelled 10 per cent. solution of D.'s serum. The other centrifuge tube now contains a compact layer of red cells in the bottom and an upper clear layer of mixed serum and salt solution. This upper layer is carefully poured off and the same amount of fresh normal salt solution is added, with a pipette, so as to thoroughly mix the cells. The tube is again centrifuged. This procedure is repeated ten or twelve times in order to thoroughly wash the red corpuscles free of serum. Finally, 1 c.c. of the corpuscles is mixed with 9 c.c. of normal salt solution in a test tube and labelled 10 per cent. suspension of D.'s corpuscles. Ten cubic centimeters of blood are collected in the same way from the recipient (R.) and a 10 per cent. solution of serum and a 10 per cent. suspension of cells are prepared as above and placed in separate test-tubes. These four 10 per cent. solutions and suspensions are used in setting up the test.

In a clean test-tube 1 c.c. of D.'s serum is mixed with 1 c.c. of D.'s corpuscles. In a second tube 1 c.c. of R.'s serum is mixed with 1 c.c. of R.'s corpuscles. These two tubes are used as controls. In a third tube 1 c.c. of R.'s serum is mixed with 1 c.c. of D.'s corpuscles and in another tube 1 c.c. of R.'s corpuscles is mixed with 1 c.c. of D.'s serum. These four tubes are placed in the incubator at 37.5° C. for two hours, during which interval the tubes are shaken several times. They are then placed in the icebox for twelve hours and shaken occasionally to ensure mixing. If the blood cells remain as a layer in the bottom of the text-tubes and there is a clear, nearly colorless fluid above, or if the tube, when shaken, be quite cloudy and not transparent there has been no hemolysis. If there are no red cells present as a layer, or if the shaken tube is clear and wine-colored, there has been hemolysis of the red cells. The two control tubes should show no hemolysis. If they do, there has been an error in technic.

Agglutination Test.—During the past year the writer has been determining the hemolytic action of the blood by the Moss method, the technic of which has been modified by Brem.[1] This method is based on the principle that before the serum of one blood will cause a hemolysis of the corpuscles of another it will first, or simultaneously, cause an agglutination of the corpuscles. The reverse, that all cases that show agglutination will also show hemolysis, is not necessarily true, only occurring in about 20 per cent. of cases. Adopting this principle, all bloods are classified according to the agglutinative properties of their elements into one of four groups. In selecting a donor it is always advisable to have a donor whose blood belongs to the same group as that of the patient. If this is impossible the donor's blood should belong to a group whose corpuscles are not agglutinated by the serum of the patient. The bloods of Group IV answer this requirement for all the other groups, as its corpuscles are not agglutinated by the serum of any group. Fortunately, group IV is the most common group, Moss having found that 43 per cent. of all individuals belong to this group.

Moss found that all bloods, whether normal or pathological, could be classified into four groups by agglutination tests of the serums against the corpuscles. He found the groups to be as follows:

[1] Jour. Am. Med. Assn., July 15, 1916.

Group I. 10 per cent. Serum does not agglutinate corpuscles of any group. Corpuscles are agglutinated by serum of II, III and IV.

Group II. 40 per cent. Serum agglutinates corpuscles of groups I and III, not IV. Corpuscles agglutinated by serum of III and IV, not I.

Group III. 7 per cent. Serum agglutinates corpuscles of groups I and II, not IV. Corpuscles agglutinated by serum of II and IV, not I.

Group IV. 43 per cent. Serum agglutinates corpuscles of groups I, II and III. Corpuscles are not agglutinated by any serum.

The serum of one group will not agglutinate the corpuscles of blood belonging to the same group.

Serum \ Corpuscles	Group I	Group II	Group III	Group IV
Group I	0	0	0	0
Group II	+	0	+	0
Group III	+	+	0	0
Group IV	+	+	+	0

Moss chart, showing the reaction of the various groups against each other.

In grouping, the unknown blood should be tested with a blood whose group is known. This "standard" blood must belong to either group II or III in order to be of any value in grouping other bloods. The group to which a blood belongs becomes fixed by the third year of life, and remains constant. It is not influenced by age, disease or transfusion of blood belonging to another group.

It will be seen from the above table that the serums and corpuscles of the same groups do not in any way interact. It will also be noted that there is a wide, undetermining variety of reactions possible in the cases of group I and IV. The reactions in the two remaining groups are more limited and definite, and for that reason, groups II or III only may be used as the standards in the Moss test.

The basis of the blood examination for transfusion is the agglutination reaction. Agglutination is considered as an early stage of hemolysis and is always present, hemolysis never occurring without a primary agglutination of the blood cells, while, on the other hand, agglutination may occur, and does occur without hemolysis. It is from this agglutination that we arrive at our conclusions. The serum of a given blood contains a protective agent (antihemolysin) for its own corpuscles, this serum having a tendency to prevent hemolysis. The serum does not contain a corresponding antiagglutinin, so hemolysis may be prevented without in any way hindering the agglutination reaction. In the original method of Moss, two platinum loopfuls of the agglutinating serum were added to one loopful of corpuscles from the blood to be tested. By this method oftentimes the stage of agglutination was so transient that its presence was not recognized, and the agglutination went on to complete hemolysis. The correct interpretation of the test was therefore impossible, as the observer failed to recognize the determining factor: agglutination. To remedy this, Brem, besides the two loopfuls of agglutinating serum and one loopful of the corpuscles of the blood to be tested, added one loopful of the protecting serum, that is, serum of the same blood from whence the corpuscles were derived. This protective serum, as we stated above, contains antihemolysins but no agglutinins. In this way the agglutination is not in any way affected, but the hemolysis of the blood cells is retarded or prevented, so giving a relatively slow, definite, easily recognizable stage of agglutination. The technic, based upon these considerations, is as follows:

Ten to twenty drops of blood are collected in a small test-tube from the lobe of the ear. This is allowed to clot and then the tube is centrifuged so as to obtain a clear serum above. This is the protective serum when used with its own corpuscles, but when it is used with the corpuscles of another blood it is called the agglutinating serum. In another small test-tube are collected 2 drops of blood in about 1 c.c. of solution composed of 1.5 gm. sodium citrate, 0.9 gm. sodium chloride in 100 c.c. of distilled water. This gives approximately a 5 per cent. suspension of the corpuscles. This tube requires no further preparation.

Upon cell slides rimmed with petrolatum to prevent evaporation are made ordinary hanging drops.

On one slide is placed:

Two loopfuls of standard serum (agglutinating serum), plus

One loopful of the suspension of corpuscles of the blood to be tested, plus

One loopful of the protecting serum; that is, the serum from the same blood as the corpuscles.

On the other slide:

Two loopfuls of the unknown serum (of the blood to be tested), plus

One loopful of the suspension of corpuscles from the standard or known blood, plus

One loopful of its protective serum.

It will be seen from the above table that one slide contains the standard or known serum, while the other the standard or known corpuscles. Deductions are made, using the standard serum and corpuscles as a basis (group II or III used as the standard groups) after the agglutination is recognized.

For instance, if using group II as a standard we get agglutination in the slide containing the standard serum and none in the slide containing the standard corpuscles the undetermined blood is of group I. From the above table we will find that the serum of the standard blood (group II in this case) agglutinates the corpuscles of groups I and III and not of groups II or IV, and that the corpuscles of this standard group II are agglutinated by the serums of groups III and IV and not by groups I or II. Then, since there is agglutination in the slide containing the serum of the standard group II the undetermined or unknown blood must be either of group I or III. In the other slide containing the corpuscles of the standard group II there is no agglutination, so the undetermined or unknown blood must be either of group I or III. Since group I satisfies the agglutinating reaction in both instances the unknown blood must belong to that group.

If agglutination occurred in both slides prepared as stated above, by similar deductions we find the undetermined blood would belong to group III, as the standard serum agglutinates the corpuscles of groups I and III and not of groups II or IV, while the standard corpuscles are agglutinated by the serums of groups III and IV and not by groups I or II. As the serum and corpuscles of group III satisfy the agglutinating reaction in both instances the blood being tested belongs to that group.

Taking the third possible reaction, if no agglutination occurred in the slide containing the serum of the standard blood, and agglutination was present in the slide containing the standard corpuscles, the undetermined blood would be of group IV, since, from the table given above, we see that the standard blood (group II) agglutinates the corpuscles of groups I and III, and not of II or IV. The standard corpuscles of group II (the standard blood used in this instance), are agglutinated by the serums of groups III and IV, and not by I or II. Therefore the serum and corpuscles of group IV satisfy the agglutinating reaction of group II, the standard; consequently, the blood tested belongs to group IV.

Lastly, if there occurs no agglutination in either slide, the unknown blood is of the same group as the standard blood used, as bloods of the same group do not in any way interact.

These are the four possibilities in using group II as a standard. The method of deduction is identical to that given above when using group III as the standard.

An endeavor should always be made to have the donor and the recipient of the same group, so reducing to a minimum the possibilities of reactions. If, in an emergency, blood must be given immediately, or if the recipient be a member of group I or III, the rarer groups, certain deviations, may be practised in which bloods of unlike groups can be used. Under such conditions, the serum of the recipient must never agglutinate the corpuscles of the donor, while the serum of the latter may agglutinate the corpuscles of the patient. The serum of the donor, as it enters the blood stream of the recipient, is diluted to such an extent as to be practically inactive. The lack of agglutination of the patient's corpuscles is in part prevented by the fact that the recipient's corpuscles are protected by his own serum: *i. e.*, the protective serum.

Vincent's Method of Determining the Moss Grouping of Blood.—Because of the technical difficulties of grouping bloods in a private home without any laboratory facilities, Vincent worked out a method by which a patient's blood group can be determined in from three to five minutes, requiring no laboratory facilities.

In making the test one must have on hand a stock serum from an individual whose blood belongs to group II and from one in group III. These stock serums are obtained by drawing blood from an individual in group II and from one in group III. The serum is separated from the blood by centrifuging or allowing the blood to clot, the serum from which is placed in a sterile bottle. The serum is preserved by adding to it enough sodium citrate to make a 1.5 per cent. solution and chloroform is added to the extent of .3 per cent. These serums, when sterile, can be kept indefinitely.

Technic of Grouping the Blood.—One drop of group II serum is placed on a glass slide near one end, and one drop of group III serum on the same slide, near the other end. A drop of blood from the person to be grouped is mixed with each of the serums on the slide and the reaction noted. Clumping of the corpuscles, if it takes place, will occur in from one to three minutes, and can be readily seen with the naked eye, appearing as a brick red deposit. The various groups will be noted by the following reactions:

1. If agglutination of the corpuscles takes place in the group II serum and not in the group III serum, the blood being grouped belongs to group III.
2. If agglutination is noted in the group III serum and not in the group II serum, the blood being grouped belongs to group II.
3. If agglutination is noted in both group II and group III serums, the blood being grouped belongs to group I.
4. If agglutination does not occur in either serum, the blood being grouped belongs to group IV.

When noting the reaction, if, by simply looking at the slide with the naked eye there be any doubt as to whether or not agglutination has taken place, this can be definitely determined by placing the slide under the microscope. From the above it may be noted that if one has on hand a stock serum belonging to group II and to group III, the technic of grouping blood is very simple and can be done in a few minutes, even without laboratory facilities. The simplicity and rapidity with which it can be done is the only advantage it has over Brem's technic as previously described.

The determination of the hemolytic reactions of blood by the Moss method in the selection of donors, has proved very satisfactory in our hands. Since adopting this method, three hundred and fifty transfusions have been made without encountering a single case of hemolysis. The milder reactions have been rare. These have been manifested by a chill in 5 per cent. of the cases and by a rise in temperature occurring on the same or following day in 10 per cent. of the cases.

Except in extreme emergency, one is never justified in making a blood transfusion without first having made a hemolytic test between the two bloods to be mixed. Even between near relatives, such as sister to sister or parent to child, etc., severe fatal hemolysis may occur from mixing the two bloods. In case of a large family in which the father and mother are not in the same blood group, usually some of the children will be in the same group as the mother and some in the father's group, and occasionally, some in still another group. Thus it is plain that a brother might be a suitable donor for one brother but not for another; also, he might be a suitable donor for one parent and not for the other, thus making it a dangerous procedure to transfuse one member of a family from another member without first determining the hemolytic action of one blood with the other.

Methods of Transfusion.—1. Direct method by means of:

(*a*) Suture of vessel to vessel as practised by Carrel, Murphy and others.

(*b*) By use of a paraffin-coated cannula interpolated in the blood stream as devised by Brewer[1] and the two-piece tube of Bernheim.[2]

(*c*) By use of one cannula, bringing intima to intima as represented by the Crile method.

2. The indirect methods:

(*a*) Needle and syringe method of Lindeman[3] and Crotti.[4]

(*b*) The direct and indirect valve and syringe method of Miller,[5] Unger[6] and others.

(*c*) The indirect paraffin tube methods of Kimpton and Brown,[7] David and Curtis[8] and Percy.[9]

(*d*) By drawing blood into a receptacle containing anticoagulants, such as the citrate methods of Weil[10] and Lewisohn,[11] and the use of Herudin by Satterlee and Hooker.

(*e*) The method of drawing blood into a receptacle, defribinating, then injecting the defibrinated blood into the vein through a needle.

The direct method of transfusion by bringing intima to intima would be the ideal method were it not for the fact that it requires expert surgeons to perform the operation and that there is no way of determining with any degree of accuracy the quantity of blood transfused. On account of the technical difficulties of the operation the direct methods of transfusion have been almost entirely replaced by the various indirect methods.

Percy's Method of Transfusion.—The method is an indirect, closed method and consists of drawing blood into a specially designed glass tube and then injecting it into the vein of the recipient. The tube is coated inside with solid grocers' paraffin and liquid paraffin is floated

[1] Jour. Am. Med. Assn., January 30, 1909.
[2] Ibid., October 9, 1915.
[3] Am. Jour. Dis. of Child., 1913, vi, 28.
[4] Surg., Gynec. and Obstet., 1914, xviii, 236.
[5] Medical Record, September 11, 1915.
[6] Ibid.
[7] Jour. Am. Med. Assn., July 12, 1913.
[8] Ibid., lxii, 775.
[9] Surg., Gynec. and Obst., September, 1915.
[10] Jour. Am. Med. Assn., January 20, 1915.
[11] Am. Jour. Med. Sc., 1915, cl, 886.

on top of the blood, preventing the blood from coming in contact with the air.

Description of Tube.—The tube to be described is a modification of the Brown tube, which was changed with the object of making a venous transfusion tube and also a tube more easily constructed. It consists of a glass cylinder, 5 cm. in diameter, with a cannula leading from one end, the other end being drawn out into a tube about 1 cm. in diameter, to which a Y-connection containing a two-way valve is made. To one arm of the Y a rubber tube is attached for suction to aid in filling the tube and to the other arm a rubber bulb is connected to aid in injecting the blood. The tube differs from the Brown tube in that there is no side tube coming off from the cylinder, and the upper end of the cylinder, instead of being closed with a large cork, is drawn out into a tube for the Y connections, as described above. The cannula part of the tube is so constructed that it can be inserted directly into the vein of the donor and then into the recipient. An open dissection of the vein of both donor and recipient is made for two reasons: (1) If the operation were done subcutaneously, it would be necessary to use a needle with a rubber connection to the cannula, which connection would make a roughened area which would favor clotting, whereas with the smooth, paraffin-coated cannula there is no such tendency. (2) After the tube is filled with blood, the cannula can be inserted into a vein of the recipient without delay, an essential feature because of the tendency to clot after blood has been withdrawn.

Preparation of Tube.—The tube should be cleansed by washing with water, alcohol and then with ether, and, after it is perfectly dry, 2 ounces of melted grocers' paraffin are poured into the tube through the upper end. It is then wrapped in a towel and placed in a steam autoclave for fifteen minutes under fifteen pounds' pressure, after which, with sterile rubber gloves over the hands, the tube is rolled around while cooling so that every part of the inside is covered with melted paraffin and any excess allowed to run out of the large end. Care should be taken not to allow the cannula to become plugged with paraffin. If it does the tip is warmed over a flame and the paraffin allowed to run back into the tube. Sterilizing the rubber tubing, Y-valve and mouthpiece is done by placing them in a towel and autoclaving in the same way and at the same time as the transfusion tube or boiling them for twenty minutes. The atomizer bulb is thoroughly washed with alcohol to sterilize it. When ready to use the connections are all made and 2 ounces of sterile liquid paraffin aspirated into the tube through the cannula by means of suction at the mouth-piece. A simpler method of sterilizing the tube consists of first pouring the melted paraffin into the tube, then carefully heating the tube over a gas-burner until the paraffin in the tube begins to smoke. The excess paraffin is allowed to run out of the tube and the tube is carefully rolled with the hands while the paraffin is cooling, thus evenly coating the entire tube.

Technic of Transfusing the Blood.—The arms of both the donor and the recipient are prepared as for a surgical operation. Proper constric-

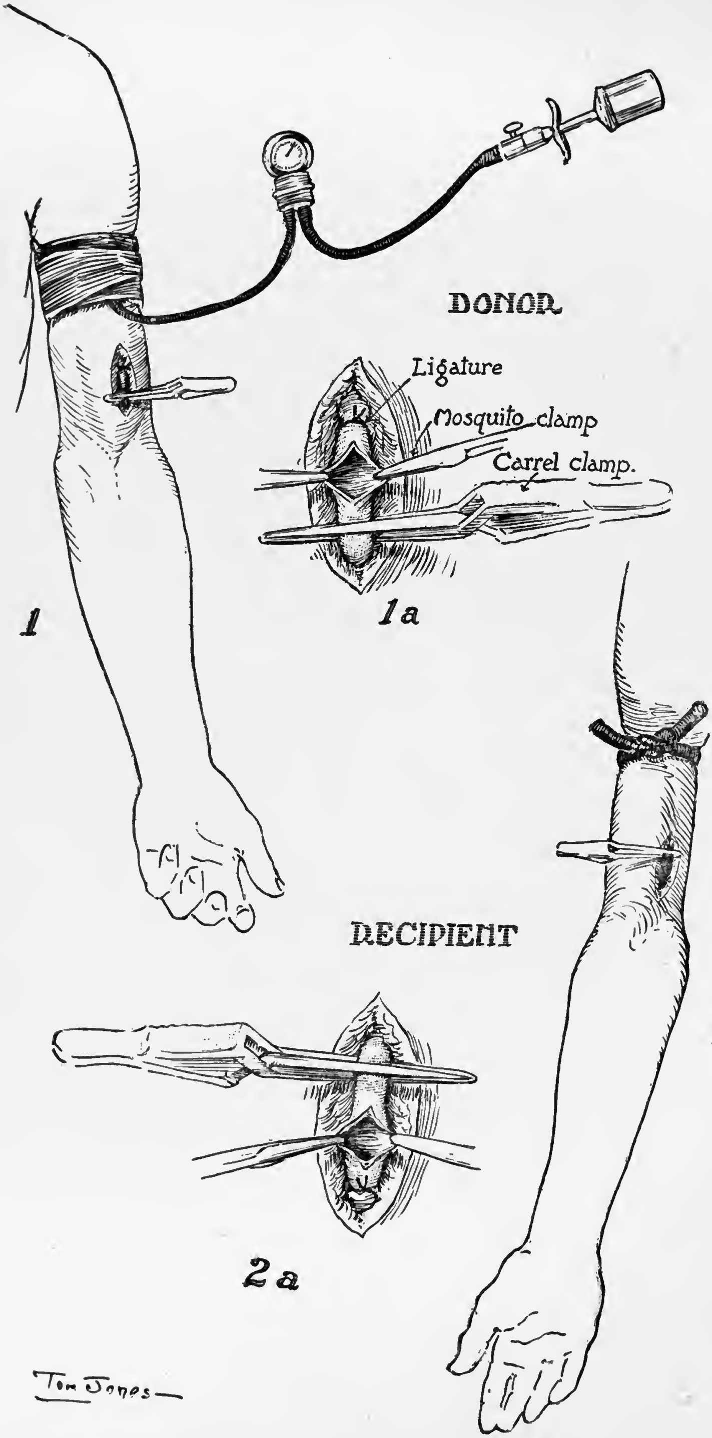


FIG. 2.—*1*, *2*, preparation of the arms of donor and recipient for blood transfusion; *1a*, *2a*, dissection of the veins of donor and recipient shown in detail. (Surgical Clinics of Chicago.)

Fig. 3.—*3*, method of obtaining blood from donor. Note layer of liquid paraffin floating on blood. Insert shows detail of the two-way valve. The operator and his assistant hold the vein over the cannula by means of traction on the mosquito clamps. Gentle suction is made by a second assistant. *4*, the cannula of the transfusion tube inserted in the vein of the recipient. The edges of the vein are held in the same way. Gentle air pressure is applied above the blood chamber by means of a rubber atomizer bulb. (Surgical Clinics of Chicago.)

tion of the donor's arm is essential if one wishes to draw off a large quantity of venous blood rapidly. Constriction by means of a rubber tube is not satisfactory because the amount of pressure is not known, nor can the pressure be varied as desired. An ordinary blood-pressure apparatus placed about the arm and pumped up to 50 to 80 mm. of mercury, depending upon the rapidity with which the blood flows, makes an excellent constrictor. By this means the venous circulation is impeded but not the arterial, thus making the entire arm a blood reservoir, and so increasing the pressure in the vein elected.

It is imperative to use a separate set of instruments on different tables for donor and patient in order not to transmit infections from patient to donor. Under local anesthesia, using 0.5 per cent. novocain solution intradermally, an incision is made over the cephalic vein just above the elbow on both the donor and the recipient, and a ligature placed about the vein on its proximal portion in the donor and on its distal portion in the recipient. Small Carrel clamps are placed on that portion of the vein away from the ligature in each patient and a longitudinal incision 3 mm. long made through all coats of each vein midway between clamp and ligature. Small mosquito retention clamps are placed on the two edges of the incision in each vein in order to hold them open.

Just before the tube is inserted into the donor's vein about 25 c.c. of sterile liquid paraffin are aspirated into the tube. The cannula is placed, pointing distally, into the vein of the donor, and the Carrel clamp released from the vein. Slight suction will facilitate filling of the tube with blood. The blood is well protected from the sides of the glass by the paraffin coat. As the tube fills the liquid paraffin floats over the blood, thus preventing the blood from coming in contact with air. As soon as the tube is filled, which in our experience averages about three and one-half minutes to withdraw 600 c.c. of blood, the Y-valve is closed, the cannula removed from the vein and the small clamp reapplied to the donor's vein.

The cannula is now quickly transferred to the lumen of the vein of the recipient and the Carrel clamp released. The blood will now flow into the vein of the recipient toward the heart, the velocity of which flow may be controlled by careful pumping of the rubber atomizer bulb. As soon as it is evident that the blood is flowing properly an assistant may release the constrictor from the donor and ligate the vein distally to the opening from which the blood has been taken. Not more than five minutes should be utilized in obtaining the blood. The tube can be emptied in about a minute and a half, but greater deliberation is advisable, so that possible hemolytic phenomena may be noticed, acute dilatation of the heart avoided and that aëration of this venous blood may be more ready. Inhalation of oxygen in very weak patients is advisable during the injection of large amounts of venous blood. The length of time required to fill the tube with blood varies with different donors. It is well to have two tubes ready, so that if it is found that the first tube fills slowly, taking more than five minutes to get the required amount, the process may be repeated with the second tube, aspirating only the remainder of the required amount of blood.

Factors of Safety.—The chief points to be borne in mind in blood transfusion are the avoidance of hemolysis, air ambolism, clot embolism and acute dilatation of the heart.

The greatest risk from the operation is that from hemolysis. This danger can be avoided in the vast majority of cases if careful hemolytic and agglutination tests are always made preliminary to transfusion. While laboratory methods have their limitations and are not infallible, still, if the tests are always carefully made, the danger from hemolysis is slight.

The danger from air embolus and clot embolus can always be avoided if proper care is exercised in carrying out the technic of the operation.

The danger of acute dilatation of the heart is probably not as great as is generally supposed. So far the author has not encountered a case in which there was any evidence of the heart having been embarrassed by the transfusion. It is well, however, not to inject the blood too rapidly in very weak and anemic patients, especially if it be the first transfusion.

Advantages of the above method of transfusion are:

1. Known quantities of blood may be administered.
2. As much as 600 to 700 c.c. of blood can be given in from five to eight minutes.
3. Venous blood is utilized, so that arteries, such as the radial, are not destroyed.
4. Transfusion can be made without danger of contaminating the donor with the blood of the recipient.
5. The blood does not come in contact with the air during the entire operation.
6. There is direct communication between the vein and the chamber by a simple paraffin-lined glass cannula. There are no metal, rubber or other connections which might cause resistance to the flow of blood and thus favor the formation of a clot.
7. Plain, whole blood is administered in its normal state. The blood is not diluted with any foreign substance and not traumatized by beating, as in the citrate method; nor is it traumatized by passing through a series of valves and connections, as it might be in some of the other indirect methods of transfusion.

Reactions following Transfusion.—The majority of our patients have experienced no noticeable reaction whatsoever. In about 5 per cent. of cases a slight chill has occurred, followed by temperature, and in an additional 5 per cent. a mild temperature developed the same evening or day following the transfusion. This applies to transfusions in which the patient and donor were in the same blood group, as classified by Moss. Whenever we deviated from this and used a donor from a different blood group than that of the recipient, as was occasionally necessary, the transfusion was usually followed by a marked chill and temperature. A donor from a different group than that of the recipient was never used except when the patient was in one of the rarer groups and it was difficult to find a donor belonging to the same group. In these instances a donor was chosen from group IV, a group whose corpuscles would not be agglutinated by the serum of the recipient.

A number of operators using the citrate method have noted a comparatively high percentage of reaction following transfusion. This is probably due to two causes: (1) the introduction of the sodium citrate into the circulation, which may be slightly toxic to some individuals; (2) the whipping of the blood and exposure to the air in mixing it with the citrate solution may cause some change in the blood which, when injected into the circulation, may help to account for the chills and temperature.

The clinical effect of transfusions apparently is not impaired by these slight reactions, which not infrequently do occur. Novy's[1] experiments in the toxicity of normal blood serum are interesting. He believes that normal serum is always toxic and that the effects produced by the injection of serum vary with the method of preparing the serum. A serum made by defibrinating with glass beads was found to be more toxic than one prepared by simply whipping with a glass rod. He also found that with whole blood some change takes place in the blood by being out of the body a few minutes, rendering the blood toxic. This is illustrated by the following experiment: When 10 c.c. of blood were drawn from a rabbit and injected intravenously into a guinea-pig with the least possible delay it caused very little or no reaction. On the other hand, when such blood was kept in the syringe for three minutes before it was injected the blood became toxic, 2 c.c. of which was sufficient to kill the animal.

The symptoms of hemolysis or "anaphylactoid" phenomena, as spoken of by Brem, which follow transfusion when one blood is incompatible with the other are quite typical, and, as a rule, occur within a few seconds from the time the transfused blood first enters the circulation. Before using the Moss group method of selecting donors the author met with three of these severe reactions, two of which resulted fatally, one living twenty days and the other twenty-one days after transfusion. The symptoms were practically the same in all 3 cases; the 2 which resulted fatally ran practically the same course.

The following report illustrates the symptoms and course of a case of hemolysis from transfusion. The case transfused was a tuberculous patient, suffering from Pott's disease with psoas abscess, also tuberculosis of the ribs. On making a hemolytic test a marked hemolytic reaction existed between her blood and her husband's, but a test with the sister's blood was negative, so she was chosen as the donor. Five hundred cubic centimeters of blood were taken from the donor and after about 250 c.c. had been given to the recipient, she suddenly complained of a peculiar feeling over her entire body and of severe pain low down in the spine radiating along both sciatic nerves. The transfusion

[1] Jour. Am. Med. Assn., July 15, 1916, p. 193.

was stopped immediately without giving the remaining 250 c.c. of blood in the tube. Chills and vomiting began at once. A peculiar biuret-pink blush flushed the woman's face and body, being strikingly intense on the palms. Sweating, so profuse that droplets formed on the fingers and the palms, was noted immediately. Great respiratory distress accompanied these signs, persisting somewhat longer than the characteristic blush which quickly changed to a transient cyanosis, as though the capillaries had been suddenly gorged to their full capacity and then had suddenly contracted to their utmost. This entire chain of symptoms occurred within three minutes of the beginning of transfusion. The vomiting and chills persisted in their full intensity for about one hour, when the temperature mounted to 101°, returning to normal within twenty-four hours. The vomiting continued, regardless of food (bile and mucus), at intervals of from a half to a few hours. Two hours after the transfusion bleeding began from the uterus and the small cutaneous wound in the arm, and it was uncontrollable except by tight compression of the entire arm and heavy sealing of the wound with collodion. Bleeding subsided within twelve hours.

Six hours after transfusion a peculiar yellow color, different from yet suggesting jaundice, made its appearance over the entire body, including the scleræ. This color disappeared in thirty-six hours. Within two hours after transfusion blood appeared in the urine. This was followed by a complete suppression of urine, persisting for thirty-six hours, when 2 ounces were passed in the next twenty-four hours. The quantity of urine increased about 2 ounces daily to 10 or 12 ounces.

One week after transfusion an urticaria appeared over the entire body, persisting for about a week, and being followed by a peeling resembling the scaling of a scarlet-fever rash. Constant nausea and vomiting persisted without abatement. The patient gradually lost strength and died at the end of three weeks without evidence of any terminal infection.

It may be noted that the donor in this case was the patient's sister.

Summary.—1. Transfusion of blood is the most efficient means at our command for treating hemorrhage and the majority of hemorrhagic diseases, as well as many of the wasting diseases.

2. The proper selection of donors by adequate preliminary tests for compatibility is essential.

3. Amounts of from 500 to 800 c.c. of whole blood, repeated at intervals of seven to fifteen days, are most desirable.

4. A simple, rapid method of transfusing should be used. This should preferably be one in which plain, whole blood is administered, without mixing with any foreign substance; furthermore, the blood should not be unduly exposed to the air, and the interval that it is out of the circulation should be reduced to a minimum. An indirect, closed method by means of a prepared container seems to best answer these requirements.

EFFICIENCY OF RADIUM IN MALIGNANT DISEASE.

By ROBERT ABBE, M.D.

In considering the subject of this title, we must ask ourselves two questions:

1. What can we regard as definite knowledge of the action of radium as a physical force?

2. What effect is seen by its use, on vital growth in health and disease?

Without an intelligent appreciation of this first step we are not prepared to ask the question—

"What is its effect on malignant disease?"

Under the latter head we must also ask ourselves: "What constitute the essential characteristics of malignant tumors?"

No observer of the action of radium can fail to be impressed with its terrific penetrating force, which no material substances, even metals, are capable of resisting. The severe test, with an inch thickness of lead, shows that this is a barrier to its penetration only for a time. One thinks he is immune from its action when he carries radium in a lead box of a quarter inch thickness, but soon discovers his fingers becoming tender from it.

The many streams of penetrating particles emanate in unceasing flow from the eternal disintegration of this material. They travel in undeviating lines in all directions, and barriers of varying resistance retard them only for a time. They enter space, but are never lost in it.

The nature of this matter is now sufficiently understood to define it as a discharge of infinitely small particles mostly bearing an electric current, some positive and some negative, called "electrons." The eternal breaking up of radium particles is not unlike the change and decay that characterize all matter, and differs only in being so much faster than anything heretofore known, that it can be seen, measured, and applied. All other metals are undergoing this forcible change, but with them it is so many million times slower, that it cannot be identified, studied or used, though it can be computed.

The force we are dealing with, then, is a stream of electrons which we spray upon a diseased part and study the effect which follows. Whether we use a nearly pure salt of radium, like the pure radium bromide, or an impure radium-barium sulphate, chloride or carbonate, of one-third or one-tenth strength, we are applying the same force and obtain the same effect if we give a proportionate exposure.

It will be essential to intelligent understanding of the action and value of radium to know a little of the detailed physics of electrons. A few words comprehend the whole.

There are three kinds of particles issuing from the disintegrating atom:

One slow moving and heavier than the others, each particle carrying a charge of positive electricity ("if, indeed, it be not electricity itself,"

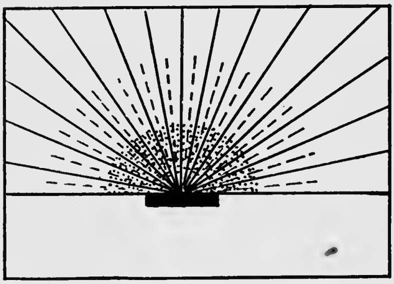


Fig. 4.—Schematic representation of alpha, beta and gamma rays from a surface of radium on a metal block.

as Clifford suggested). This alpha series travels in straight lines, but has a small radius of action.

The second, and most important, the beta series, much faster and lighter, each particle carrying negative electricity.

The third, the gamma, practically a neutral electron, travelling nearly with the rapidity of light and almost undeviated by the magnetic current.

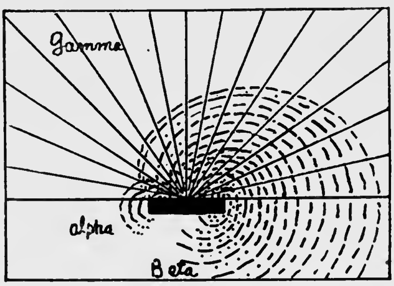


Fig. 5.—Alpha, beta and gamma rays in a strong magnetic field.

The stream of rays issuing from radium moves in straight lines in all directions (Fig. 4). When, however, it is placed in the magnetic field, between two poles of a strong battery, only the gamma rays continue to go straight while the beta and alphas go swirling around the poles, one in one direction and the other in the opposite, obeying the law of metallic particles in the magnetic field (Fig. 5). Taking advantage of this it has become possible to study the effects of the differentiated groups. Two simple experiments put the reader in the way of understanding the full value of each group. Their effect on vital growth can be demonstrated:

First experiment. Let radium be spread on a small block of lead, an inch square, placed at right angles to a photographic plate, on which are standing small lead pillars, in front of and behind the block (Fig. 6). In a few moments the developed photograph shows shadows of all columns radiating away from the radium (Fig. 7). At the foot of each column is an intensification of the illumination of the plate, due to a series of secondary rays resulting from the impact of all these groups, straight-travelling, and striking the little lead post, set up on the plate.

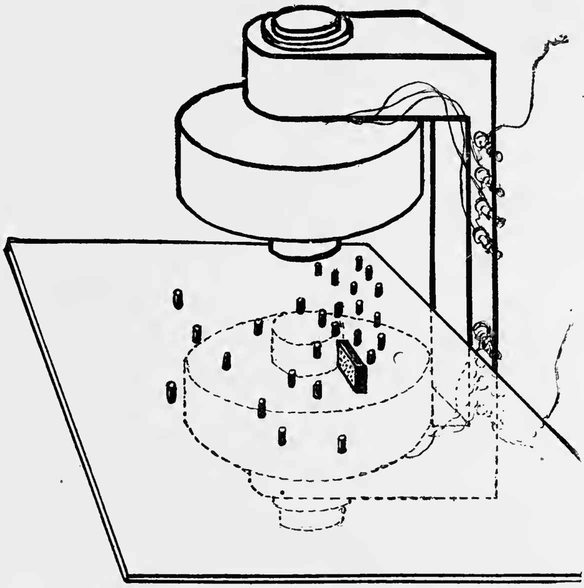


Fig. 6

Second experiment. Repeat the above arrangement of lead block, radium, and lead posts on a fresh plate and place this in the field of a powerful magnet. On developing this plate an entirely different picture is shown (Fig. 8). The posts in front of the radium again show radiating shadows, but another set now appear on one side and behind the lead block, resulting from the beta rays, torn from the straight course they were travelling hand-in-hand with the gammas, and made to swirl round the magnetic pole, in obedience with laws of electrically charged bodies, and casting curved shadows. These also have intensified illumination at the foot of each post, from secondary rays, generated always where any obstruction is met. This experiment can now be used to demonstrate the effort of isolated beta rays (negative electrons) on living cells. (Fig. 9). The device shown provides a shelf on which are showered beta and gamma rays separated. The only scientist competent to give aid in perfect demonstration at this stage

FIG. 7

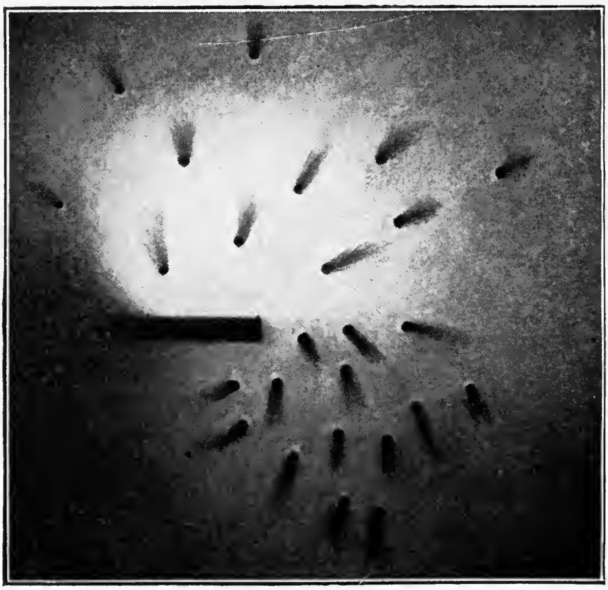


FIG. 8

I believed to be Dr. Alexis Carrel, who had been growing living cells of chicken tissue for three years by cultivation, *in vitro,* in a warm chamber under strictest guard of all circumstances. The process seemed as perfect as culture of bacteria in a test-tube. Every other day an atomic bit of new-grown cells had been cut from the margin of two days' growth, and placed in a cell or a microscopic slide, sealed hermetically in modified chicken serum. Thus, generation after generation, up to nearly three hundred, had established normal growth for each day, under identical conditions. It thus became possible to take a corresponding group of new cells day after day, repeat the old experiment and add the new ones, of an identical bit of tissue subjected to isolated beta rays and another to isolated gamma rays for a half hour, and cultivated altogether side by side for two days' growth.

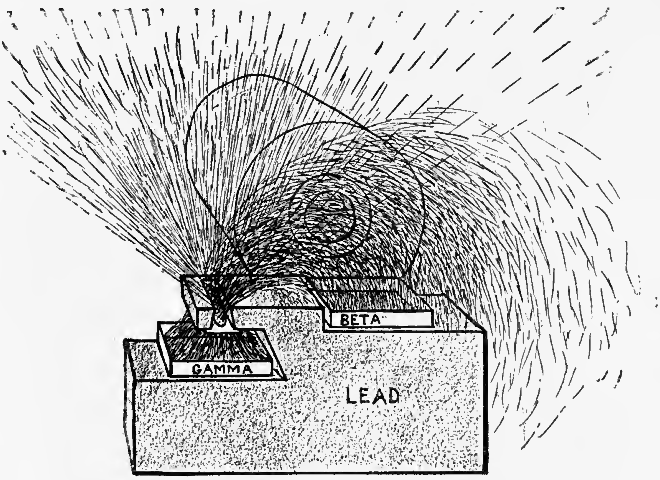


FIG. 9

This experiment Dr. Carrel eagerly took up day after day, appreciating its significance, and pursuing it for many months with the following striking demonstrations:

1. The beta ray uniformly produced great retardation of the cell growth. The gamma gave no effect.

2. This stunting of the cells was persistent, so that all attempts to make them grow like the unradiumized, failed, and through eight generations the dwarfed cells continued as dwarfs.

(Further work was prevented by Dr. Carrel's call to the service of his country).

The two illustrations of normal and stunted growth here shown are from studies in other research work by this master, but, at his request, I use them as exact illustrations of beta ray effects.

Before this beautiful demonstration was made the effects of radium on animal and plant life had been confined to the effects of mixed rays. Although from the first Bequerel had showed the deviation of small pencils of the rays in a magnetic field, no proof of the separate ray effects had been known. On seeds the stunting of growth by mixed rays of radium was demonstrated by Danlos to whom Madame Curie gave her first radium for study. Thousands of experiments on every kind of bulb flower and seed, by those of us who have had enough to make

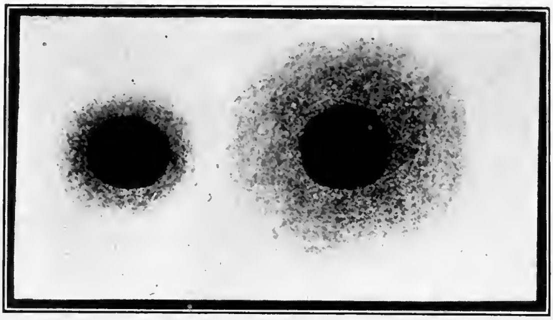


Fig. 10.—Two days' growth of living cells of chicken tissue (300th generation) dwarfed by thirty minutes' beta rays, unaffected by gamma rays.

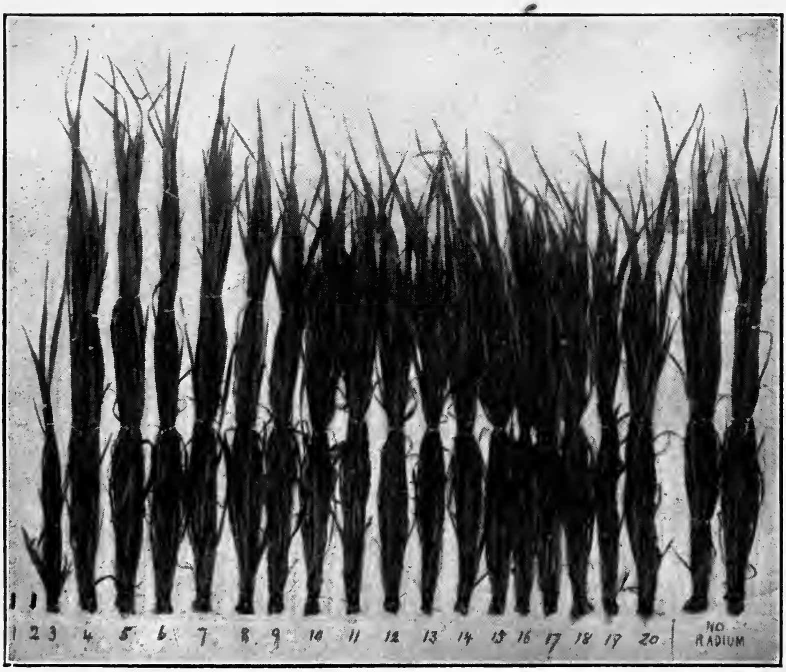


Fig. 11.—Growth of oats, exposed to naked radium at distances from ¼ to 4 inches. Twenty rows. Two rows for comparison, without radium. Exposure six days. Growth after planting, one month. Nearest two rows killed. Fourth, fifth, sixth, seventh, stimulated. Beyond seventh (1½ inches) all retarded. The nineteenth most stunted of all.

				1–1½ inch.							2 inch.					3 inch.					No radium.	
Row	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	N	N
Weight, grains	0	0	14	70	87	77	79	63	61	49	62	58	50	59	63	60	64	62	45	64	74	95
	Killed.			Stimulated.				Stunted.														

tests, all show the same. Let us illustrate by one only (Fig. 11). If oats be exposed to mixed radium rays for varying hours and planted simultaneously the longest exposed will be killed; shorter exposed will germinate and die; still shorter will grow stunted, but continue to grow or flower, dwarfed; still less exposed will grow less than normal; while some with a very small radiumizing will be stimulated and grow above the normal.

The effect on animal and vegetable life is the same. There has never been any known difference between the vital force actuating a cell of animal or vegetable structure. It is fair to say that science is about ready to admit that electricity is the basic force actuating animal life, energizing nerves and muscles, tactile sense and cerebration. The recent study of cardiography by electrical conduction, whereby disorders of rhythm and function of the heart can be studied a half mile from the bedside, stand sponsor, if any were needed, for placing the responsibility on correct electric charges for normal action of our bodies and on disordered electric action for their variations.

Having grasped this idea, we easily take the next step and note the pathological changes in the cells of our complicated bodies, indicated by stimulation, repression, decay and death.

It is reasonable to offer a working hypothesis at this stage of our study, based upon grounds consistent with our limited knowledge.

It seems reasonable to think that the orderly growth and life of a cell is due to a balance of its electric charges, positive and negative existing in each cell. When we find a small tumor composed of an overgrowth of cells normal to the part, we must admit that some force has gone out of or entered into its life which has caused the disordered growth. Its balance has been disturbed. If, at this stage, we supply it with electrons, of one or another kind, and see a rapid return to normal growth, there can be but one logical conclusion, namely, we have supplied the needed force which was lost. Just at this point we face the discovery that a shower of negative electrons freshly liberated from radium will cause a stunting of cell growth. Facts which will be demonstrated and illustrated further on are these: Growth composed of overgrown masses of cells, return to orderly growth permanently, when given the exact dosage of negative electrons are shot into them. Growths to which too much is supplied, undergo atrophy, and, if excessively oversupplied, undergo death. We may assume, therefore, that the dosage must correspond with the loss. We are thus coming closer and closer to the unfolding of one of the puzzling problems of life, viz.: What is inherent in the nucleus of every cell that causes its stability? In the cosmos we turn to students of geology, zoölogy and biology to learn what new thoughts have been evolved to elucidate a better understanding of the origin of life on the earth. Definite propositions, based on fact, have been recently set forth by Prof. H. F. Osborne in an address before the National Academy of Science. The ripe thought of scientists turns to chemistry to provide the substance and framework to explain this earliest protoplasmic development after the earth crust had cooled, and water and rock disintegration, with nitrogen, carbon and oxygen, gave material to form corporate material for electric stimulation to vitalize. These electrons originated perhaps from friction of elements, from atmospheric discharges, or, who can say, radium latent in the earth, or electrons shot through space.

It is a little surprising to see the trend of scientific thought toward electricity in recognizing the probable vitalizing life force. It lends much weight to the growing recognition of the latent force residing in radium or issuing from the roentgen tube which is counted only in terms of electrons.

It is no flight of fancy to regard the force in radium as *incorporated life* or the electrons as *imprisoned life released.* The pathologist then must take his cue from the scientist and accept the view that protoplasmic matter is endowed with one vitalizing actuating force, viz.: electricity. After its initiation, matter thus endowed proceeds on its career of more and more complicated development and combinations until infinitely complex beings like the human body are developed. In such complex machinery, however, there remains the solitary force behind the life of every component cell.

In disordered states this has been shown by the elaborate study of Lazarus Barlow, who demonstrated a measurable amount of radioactivity in the structure of cancer of the gall-bladder with gall-stones. This is not to say that radium is present, but a liberation of negative electrons due to cellular activity and disordered growth.

We may now turn to the first questions in this paper, and consider what constitute the essential characteristics of malignant disease. The grouping of enormous myriads of cells that form a complex human body, requires a harmonious interaction which staggers the imagination, but appeals to reason as essential. It is the lack of harmonious action that shows in the development of any and every curious growth, to which we give the name of *tumor*, whether it be a papilloma or horny excrescence of the skin or epithelioma, sarcoma, cancer, fibroma or myomatous tumor. They are one and all, altered cell growths, exaggerating their normal activity, and representing a disorderly unbalanced action, out of harmony with the rest of the system. It is as if a patch of grass on an even lawn began to grow luxuriantly and out of keeping with the rest of the lawn, but it is still *healthy* grass. It is a literary error to speak of "diseased" tissue when we speak of tumor structure. While this word may be rightly applied to tissues attacked by parasitic infective destructive agents, calling the structures "diseased" as we would a tree attacked by "blight," it is quite an error to apply the word to tumors, even though they may be in the end destructive. More properly we should look upon the mass of overgrown cells which from habit we call tumors, as aggregations of cells which are enjoying the excessive freedom of growth, an ecstasy of joy and growth, such as comes to an imprisoned city scholar set free in vacation spirit. The riotous overgrowth of cells normal to the site of their growth, constitutes a tumor or colony of healthy cells, which have lost their balance or equilibrium in their relations to their neighbors. In the ultimate outcome of this disorderly growth, the result is what may be called a *diseased* condition as compared with orderly, systematic community growth in the complex system of the body. That word "disease" applied to them only refers to the incidental suicidal action of the

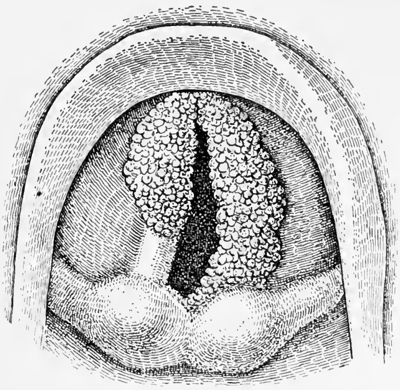


Fig. 12.—Extensive warty growth on vocal cords before cure by one radium treatment.

cell life, because it depends on nutrition supplied by the whole living organism, which its very overgrowth crowds out, so that death follows in that colony group and mars the health of the whole.

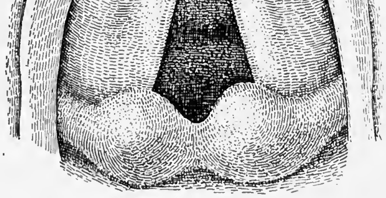
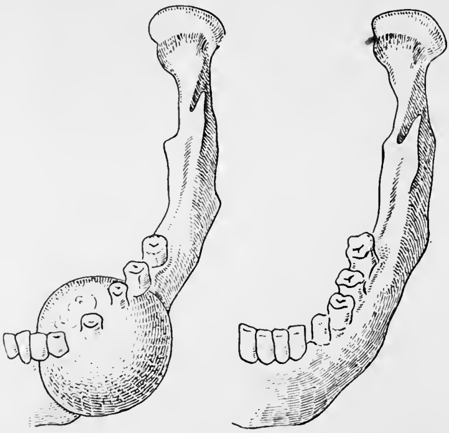


Fig. 13.—Perfect restoration of vocal cords. Return of fine singing voice continuing eight years afterward.

Malignant cells have no characteristics to distinguish them from non-malignant tumor cells, either microscopically, physically, chemically, or in responding to radiant energy. It is fair to say that certain *groupings* of cells are found in advanced malignancy, and that protoplasmic nuclei show more active mitoses indicating rapid growth, but in no particular do individual cells show anomalous character, or refuse to respond to agents like electrons of radium and roentgen ray. It is true that their successful application is full of difficulty, still to be overcome, but their efficiency in even so slight a degree encourages the belief in ultimate advancement.

Enough basis for understanding of the action of electrons on *all* cell tumors is found in the simpler forms, illustrated by papilloma and myeloids to choose only two out of many varieties. A wart, or massive overgrowth of cells of either the papillary layer of the skin or of the delicate layer of mucous membrane of the vocal cords, is identically the same type of tumor. If it is played upon by rays of radium for a few minutes it slowly disappears and leaves no traces of its existence. The same electrons have played upon the healthy cells about it but only the weak overgrown structure has changed.



A *B*

Fig. 14.—*A*, destructive myeloid sarcoma. *B*, condition of jaw fourteen years after radium cure. Jaw-bone restored to normal form and great strength, teeth solidly embedded.

If an excessive treatment has been given even the healthy growing cells are altered and a slight scar results. Otherwise nothing is damaged. To illustrate, I will cite the case of a young girl with beautiful singing voice, which first became husky, then was lost and finally left her with serious obstruction to breathing from growth of warts over two-thirds of her vocal cords (Fig. 12). Radium was applied for thirty minutes. Three months later, the warts were entirely gone and her voice restored. Her singing power returned later and was even sweeter than ever. Five years later this perfect condition continued (Fig. 13). Thus exact dosage corrected erroneous growth, without damage to normal cells. As a second illustration, I will cite a case of myeloid tumor of the lower jaw, cured by radium and followed by complete restoration of the bone, a result never previously obtained by surgery. A lad of seventeen years, had a soft tumor on the left side of his lower jaw, absorbing the entire bone except a thin strip on one edge. The swelling was several times the natural thickness of the bone, and three teeth were loosely held in it ready to drop out (Figs. 14 and 15). The tumor was treated by radium only. In a few weeks it became gritty throughout with newly regenerated bone. The tumor shrank rapidly. New bone reformed. The teeth became solid in their beds and every trace of tumor disappeared. The jaw-bone took on the identical shape of its original contour, and today, after thirteen years, it is as solid and perfect as a normal jaw-bone.

Fig. 15.—Thirteen years after treatment.

What answer can be made to the claim that here we see the alterative action of electrons reversing the disordered growth of marrow cells, of the bone, which in their riotous action were in line of destruction of the jaw and of the life of the man, if unchecked. Whether pathologists choose to class myeloid tumors as "malignant" matters little, for in their progress they were destructive to human life, and in that intent malignant. The same type of tumor in every part of the body yields in similar fashion. A dozen patients with pure myeloid growths have shown identical curative action of radium. Tumors in the lower and upper jaws, in the humerus, in the sternum, in the sacrum, in the tibia. The same alterative and curative action has been demonstrated to follow judicious use of the roentgen tube electrons by Dr. Pfahler, of Philadelphia.

The cure of epithelial tumors by radium, notably the disfiguring and destructive type of so-called skin cancers of the face, is universally admitted.

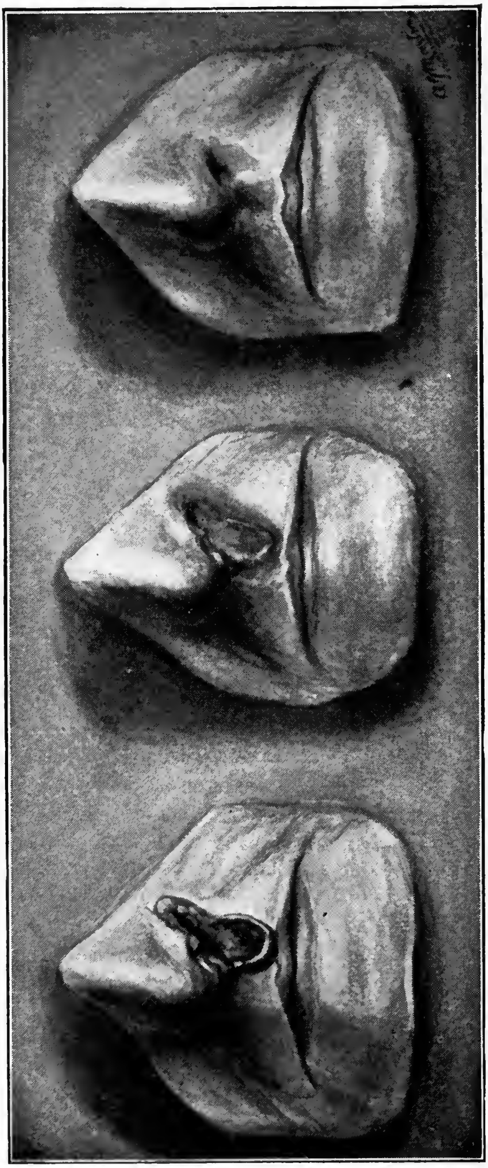
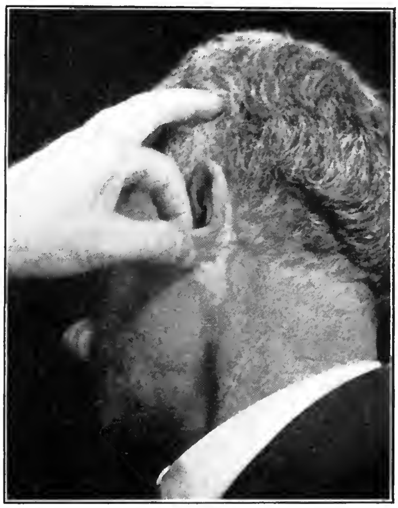


FIG. 16.—Epithelioma of the nose and upper lip, showing diminution at the end of two weeks, and disappearance at the end of five weeks.

It is no small testimony to its usefulness in surgery, but it is a greater testimony to its unique action as a therapeutic agent. Heretofore surgeons have not been able to cure this disease. They have cut it out or destroyed it by caustic acids or by cautery. Thereby they have cured the patient, but they have not cured the disease. They have only *removed* it. This new agent supplies the tumor with a force which works within itself and causes it to remove itself, if we may so

Fig. 17.—Same patient as represented in Fig. 16, showing permanence of cure by radium after thirteen years.

speak. Not only that, but if the correct dosage of electrons has been supplied, the growth never comes back. Witness the case of destruc-



Figs. 18 and 19.—Epithelial cancer, had been burned out by caustic pastes and acids for several years and recurred. Received one radium treatment only. Fig. 18 before treatment, Fig. 19 after nine years, soft scar.

tive epithelioma of the face, cured by radium, in five weeks after many years' growth. The small, smooth scar remains without return of trouble after thirteen years (Figs. 16, 17, 18 and 19) or, the case of epithelial cancer behind the ear, cured in six weeks and remaining absolutely perfect nine years later. Or, the case of epithelial tumor of the lower eyelid, cured in eight weeks and remaining cured nine years

FIG. 20.—Sarcoma of the lower eyelid, showing condition at the beginning of treatment, at the end of two weeks, at the end of four weeks, and disappearance at the end of eight weeks.

later. Serious consideration must be given to one phase of this case, illustrating clearly what may be claimed as a "specific" action of radium, that is, of a kind unlike that of any other agent. Here the lower eyelid was entirely lost, in a tumor covering more than half its length. The structures of the lid were engulfed in the growth beyond identification. The tumor was heaped up on the skin, it mounted up above the edge of the lid and grew inside the lid as upon the outside. After brief radium treatment, shrinkage rapidly ensued, the lid was evolved out of the conglomerate mass of cells and in eight weeks a normal shaped eyelid was self-restored, to speak exactly. Even the skin took on normal appearance. The edges of the lid were sharp, the mucous membrane was smooth, the eyelashes grew in again (Fig. 20). Out of the enormous mass of overgrown cells of the tumor, the original ones which constituted the eyelid and skin were reassembled and for nine years after, no one could tell on which eyelid the tumor had been.

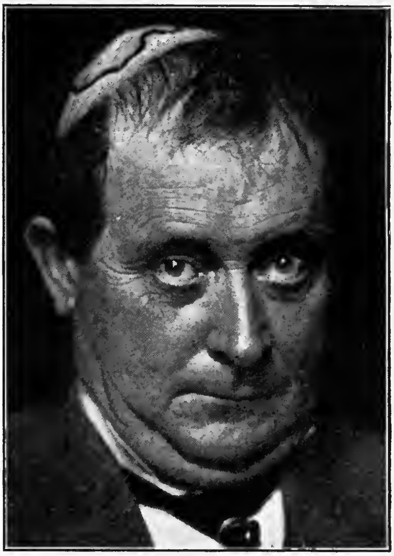


Fig. 21.—Round-cell sarcoma of the skull. Complete absorption of bone outlined by iodine.

Fig. 22.—Same case as in Fig. 21. Cured by radium.

One must evolve some theory to account for this extraordinary overgrowth of cells, which retreated, or melted away, like fog before the sun, under radium rays. Were they the product of growth of a microscopically invisible network of intercellular cells so to speak, which overwhelmed the native ones, forming the lid, and when in retreat left the original ones unharmed by the electrons which affected the new growth? Or, were they simply a hypertrophic development from excited growth of lifelong cells of the part, throwing off a generation of tender new cells of their own kind, which could not withstand the bombardment of radium electrons. In either case such types point the way to a better appreciation that we have to reckon with a new force in therapeutics from which more may be expected.

There are hundreds, yes, thousands, of cases similar to these already credited to the alterative action of electrons, and it may rightly be called a specific and unique action. Regardless of futile discussions as to what types may or may not be styled malignant, there are others that must be credited with specific cure by electrons which no other surgical method can touch (Figs. 21 and 22).

As an example, a round-celled sarcoma of the skull of a man of forty-five years had eaten through the parietal bone to an area of 4 x 3 inches. This soft vascular growth rested on the dura and elevated the skin, comprising a depth of 2 inches of tumor tissue. Enough was removed for microscopic examination and radium tubes inserted throughout the mass, lying parallel to the dura. The tumor soon disappeared and after four years has never returned. The patient has maintained perfect health and working power. Photographs before and after show clearly. The type of round-cell sarcoma is not the most common, but seems to yield with peculiar facility, while the spindle

Fig. 23

cell is intensely resistant. Periosteal tumors, mostly of spindle cell with some myeloid cells scattered throughout are not yet amenable to cure by radium; nor are the gliomas, especially of the nervous tissue. A few attempts have been, as yet, wholly ineffectual. There are certain structures which we are still compelled to excise, inasmuch as either we do not know how to use the electrons for them or they must be corrected by some yet unknown remedy (Fig. 23).

Among these are the squamous-celled epitheliomas of the skin, which usually, though not always, present a character clinically different from the basal-cell type. If one can discern one from the other, the squamous-cell type must be eradicated by caustics, cautery or the knife. This is not wholly true, however, of the cancer most commonly known as malignant. One must study the effect of radium electrons on relatively small areas of recurrence, after removal of typical scirrhus cancer, such as seen in mammary cases, to know definitely that the same specific action can easily be demonstrated there as in simple epitheliomas. It is futile, to assert that radium is ineffectual because one is called upon to excise a large, or long-standing mass of cancer. If a small beginning of one, or a part of a recurrent cuirasse carcinoma yields definite cure, its removal is quite as triumphant if radium or the scalpel brings it about.

It has long been proved, that in the early recurrences of the skin after mammary removal for cancer, radium can cause a complete

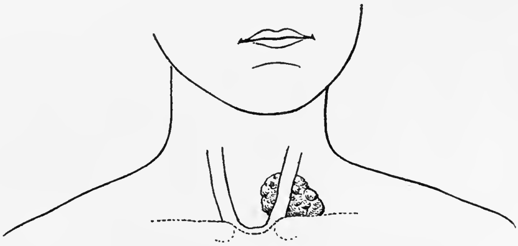


Fig. 24

melting away of moderate invasions. It only needed the greater efficiency of the Coolidge x-ray tube, in demonstrating the rapid destruction of larger cancer masses, to endorse the work of radium in similar lines. Technically one is more difficult than the other, but the principle of action by electronic discharge is the same. As an

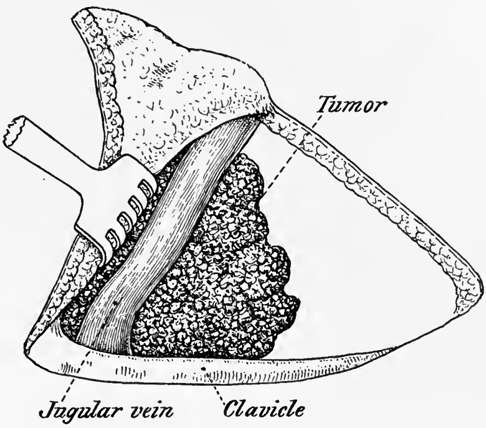


Fig. 25

illustration of radium action alone in combating the disease, let me cite the case of a lady of seventy-five years, seriously weakened and poisoned by absorption from an ulcerative and bleeding cancer of the breast. Six short, painless applications of radium caused a rapid healing and shrinking of the masses, until a small group of inert fibrous remnants about the smooth scar remained unchanged for two years. The patient died suddenly of acute nephritis, entirely unrelated to the disease.

One of the principles best illustrating the efficient use of radium in typical cases of clinical cancer was enumerated by Wickham in the early years of his work, by which he demonstrated that if the surgeon removed all possible cancer from a mass and left only a thin shell, this remnant could be efficiently controlled, for a time at least, by radium, but that it was useless and hazardous to treat masses by exerting the destructive agency of radium. This I have demonstrated by such cases as the following:

A lady whose breast showed a small typical scirrhous nodule, the size of a prune stone, permitted excision only under cocain. It was not at all wide of the disease from a surgical point of view and recurrence would have been speedy had I not given a good radium insertion embedded in the operative field. Three years have elapsed and no trace of hardness shows in the soft scar.

Fig. 26.—Perfect health eight years later. Small flat remnant left at operation now dormant.

Again, a lady of forty years presented a hard growth above the left clavicle near the sternoclavicular tendon (Fig. 24).

It was close beneath the skin and not very moveable. At operation a dense cancer mass was removed with great difficulty (Figs. 24 to 26). It lay between the jugular and carotid at their points of origin. The former was carefully dissected off but the growth adhered so tightly to the common carotid artery for an inch away from the innominate that a thin layer of tumor was necessarily left attached to it. The wound was closed except a sinus where a strong tube of radium was left resting against the shell of the cancer. After a few hours this was removed and the wound healed. Nine years have gone by and no trace of trouble has shown. Examination of the tumor showed it to be cancer. Its size was that of a half egg.

Again, on two occasions I have excised carcinomatous masses of the lower parotid gland and implanted radium tubes in the bed of the excised mass, knowing that speedy recurrence was inevitable without that sequel. In both cases more than four years have gone by and no trace of trouble can be felt in the soft cicatrix. In other cases of parotid tumors the more common mixed sarcomas, the arrest of growth has been commensurate with the amount of radium used, but slowly the recurrences have come, yet each time one feels that a heavier dosage will make an end of the local residue which the surgeon cannot see but only suspect. In all radium work diseases involving the gland structures, cutaneous, lymphatic or salivary, seem to yield better than those entering areolar or muscular structures.

Great discouragement necessarily follows all pioneer work in new fields, because, attempts must be made to test apparently hopeless trails which must be abandoned temporarily, only to be taken up again and again as new methods prevail. In this line of pursuit, hundreds

Fig. 27.—Cancer of tongue.

of advanced cases of cancer have been submitted to test, sometimes mild, sometimes heroic. Discredit and abuse have been undeservedly received. Out of all, however, it is fair to say that in grave cases much that has been helpful has resulted, and in the early cancer cases, apparent cure results. More cannot be said to the credit of surgery by cutting methods.

Let me speak in order of types of cancer in places difficult of treatment; in the alimentary tract; cancer of the tongue; mouth; pharynx; esophagus; stomach; intestines; rectum. Every surgeon knows that leukoplakia, a hypertrophic white growth of the mouth and tongue, cannot be cured by any method except radium, and that, only by most judicious use. Also, he knows that when it has become ulcerated it becomes cancerous and must be cut out extensively. It now seems that such early growths yield to radium and stay cured, at least for such time as radium has been available. Again, every surgeon knows that excision of a half tongue for typical cancer with lymphatic extirpation is almost sure to be followed by recurrence (Fig. 27). Some recent work by such surgery supplemented by radiumization of the edges without recurrence up to more than four years, suggests a happier issue than plain surgery has to offer.

Cancer of the tonsil and pharynx in advanced conditions, has little to hope from surgery alone, and but little more from radium. This is due partly to the difficulty of exact application, where salivation, choking, pain and deglutition add to the discouragement of patient and surgeon, partly to the high vascular and lymphatic supply of the part. Few good effects of radium are seen. In the nasopharynx an occasional control of the disease can be accomplished, owing to the facility of continued application of radium applications. In massive cancers of the tongue itself with foul ulceration, one sometimes can cause rapid reduction of the mass and get the sore almost healed, but sooner or later the growth takes on its wonted activity. The field is not a hopeless one, for further study of radio-active agents. The lip cancers are not yet legitimate material for cure by radium, though some superficial types have been cured. It is far better for the patient to have wide excision which usually insures future immunity.

In the esophagus, a cancer usually takes the form of a cylindrical development, with thickening on one side or the other, to a mass of half an inch or more. This is not as yet amenable to control by radium, although one would think the opportunity for exact central application of a radium tube would permit efficient action, which is true as far as radiumizing the mass goes. There are factors of peculiar seriousness in the central mediastinum which baffle the operator. One must aim at the destruction of the massive cylinder. This means ulceration, absorption, toxemia and peril to an already weak subject. The efficient dosage also implies severe radiant effect on the cardiac nervous system, and finally if the erosion and destruction of the cancer mass takes place, one must expect hemorrhage, pain, perforation and abscess from acts of deglutition, which are an unwarranted jeopardy. On the whole, therefore, the use of radium in esophageal cancer, mostly tried in advanced cases thus far, has nothing to recommend it.

The same may be said of cancer of the stomach and pylorus. Nevertheless, while one does not look for a cure, in these cases, it is possible in a few selected types to control growth and repress hemorrhage if one can have access to the disease through a gastrostomy sinus. This means technically that an internal and external use of radium in quantity sufficient to filter out the soft rays with lead, and "cross fire" the mass if accessible enough. It is fair to say, however, that here one uses mostly gamma radiation, which may probably be more penetratingly and efficiently obtained from an *x*-ray tube, or, that without, and radium within.

In malignant disease of the rectum we have several varieties known to every surgeon, and many stages of each variety. It is a fairly good field for study of radium. Let us first premise that the best surgical treatment stands today as (1) preliminary colostomy; (2) where feasible, a well considered surgical extirpation of part or of the whole rectum with the disease. The surgeon who wishes to do his full duty to his patient then has to consider whether radium offers any additional help. My judgment is that it does, if used discreetly, which means that our first duty is to advise colostomy as early as possible. It will have to come some time. It removes the incessant irritation of the growth and arrests its rapid progress. If its removal is not possible then we use radium, varying the amount and method according to conditions. The immediate effect is usually to check hemorrhage by vascular occlusion of the surface of the growth, and incidentally usually to relieve severe pain. More constant even than these results there is almost uniformly a speedy gain in color, a loss of the cachexia, whether it be anemic or toxemic, and a diminished foul secretion, from the absorption of which some of the toxemia may have resulted.

When one reviews a large surgical experience of forty years in this field and makes due allowance for the natural improvement following the simple, highly valued, colostomy, he still finds prolongation of life and relative relief from pain and hemorrhage with continual increase in color, to the credit of radium. The expected prolongation of life may be therefore estimated about double, that is to say, if when seen first, two years may be rated as the patient's hope, it may be four years if radium be used.

Experience shows that the best method of using radium, here as elsewhere, is to give as much as the part will stand at one or two seances, and then dismiss the patient for two months at least. In this way only can one estimate the gain. Usually there ensues stenosis of the lumen of the bowel as atrophy of the mass takes place. One must not deceive himself by occlusion from progress of the growth in some cases.

In uterine cancer much the same record prevails today as in rectal, except that the general trend is better. Both types are helped by radium when there is a marked adenocarcinoma, and in its early stage when the cervix uteri has erosion and cellular ingrowth into the submucous layer, this can be destroyed by radium. One such case only in my experience has endured with no return of disease twelve years. In other cases where intense radiumization has been tried out the destruction of malignant cells has gone out into the extra-uterine tissue and made inoperable cases operable. In the face of universal acknowledgment that such cases invariably return with bad recurrences (usually early), the hope of cure of early uterine cancer lies in the use of radium, or some powerful destructive agent (caustic or cautery), with subsequent operation.

When inoperable recurrences occur in the vaginal scar, usually in the vault, and spreading into the broad ligaments, the liberal use of filtered radium will at times cause a striking retrograde of the recurrence. In one case, sent to me with extensive and inoperable recurrence, after complete hysterectomy for cancer, by Dr. Robert T. Morris, followed by a second apparently thorough operation for proved secondary cancer, I was able to induce so perfect a disappearance of all the typical mass spread through the scar and broad ligaments, that for two years nothing could be felt and the patient maintained perfect health. During the third year a nodule again appeared and slowly extended. Again the radium retarded its growth, but slow extension exhausted the patient after four years. In most such cases the utmost I have been able to accomplish (having due regard to uncomfortable vaginal burns) has been to retard growth, check hemorrhage, reduce the distressing foul discharge and improve color.

The cervix occasionally shows fungating cancer protruding massively into the vagina. This type is especially amenable to curetting away, until a hard base is left, which is given a heavy radiumization. One such case in my hands lived many years and died from other causes with no recurrence. Knowledge of its full value in these cases must await some years more of study by those who have enough experience with surgery as with radium, to speak with authority. It would be useless to pursue the theme further to speak of the multiple and efficient uses of radium in other parts.

The subject is by no means ready for encyclopedic conclusions. The field is open for progress in both efficient and wider usefulness, and for technical improvement in its applications. It seems, at present, that its greatest benefit comes from using, at will, the Beta rays, mixed with gamma as given off from applicators and tubes, or, in suitable cases, by enveloping it with metal of varying thickness to utilize the penetrating gamma rays alone with no risk of burning the skin or mucous membrane. In both cases, a cross-fire attack upon the disease by an opposing radium applicator as correctly credited to Wickman, is without question the surest way to promote its good work.

It seems to the author that malignant cells are not inherently different in their nature from other living cells. They have a different coefficient of resistance, so have spindle cells, and others, but that they do respond to radium has been proved, and can be demonstrated in recurrent nodes under the skin in breast cancer cases.

Fig. 28, made for me by Dr. F. C. Wood, demonstrates clearly the sphere of influence, though it be small, which a tube of radium has when laid on the skin over such a nodule. Technical methods remain undeveloped, but the efficiency of radium as a new force must be reckoned with in the future of surgery.

Technical Application.—No good result can be expected from the use of radium without earnest study on the part of the operator. It has long been the expressed opinion of the author that no one who ventures to use it in practice should do so without first testing his particular specimen or specimens upon his own skin. While there is probably very slight difference in idiosyncrasy of patients to its action, there is the greatest difference in the working efficiency of each specimen. This is due to the fact that any ten milligrammes may differ in purity, or in its container, that is, it may be sealed in a thin or a thick glass tube, or in a tube of metal, or spread on a metal plate (plaque) embedded in varnish or enamel. To speak therefore of the number of milligramme-hours that may serve to produce a certain efficiency is quite uncertain. It is evident that ten milligrammes confined in a very small tube affects a local area close to it, while, when spread on the surface of a metal plaque, the size of a quarter dollar, its effective radiumization of the same area covered by the tube would take longer.

The author has long held that no physician can so well work with his own specimens, or understand so well the working of radium, as he can when he has first tried it on himself. He may best choose perhaps the inner side of the calf of his leg for this test. Let the application be placed on the skin, at three nearby spots, for different periods say, five, ten, and fifteen minutes for very strong specimens, or twice

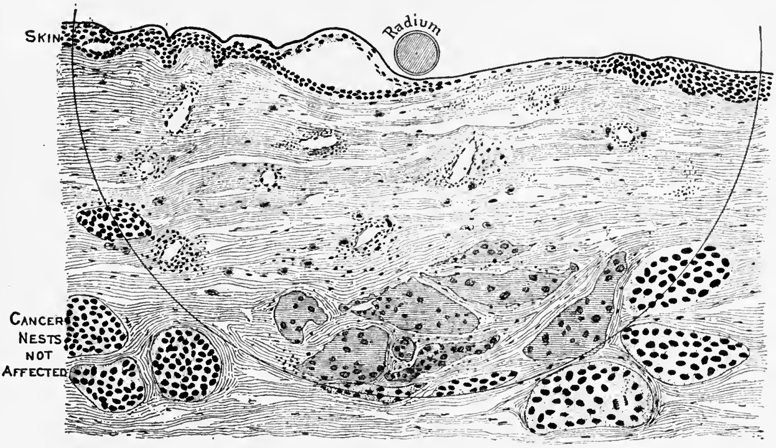


FIG. 28.—Showing sphere of influence with dead cancer nests. Recurrent subcutaneous nodule degenerating under one radium application.

that time for weaker ones. The effect should begin to show in ten days as a dermatitis; itching, burning and perhaps blistering in the following ten days; subsiding and forming a dry crust during the third ten days. On the thirtieth day the crust falls from a smooth skin. This is about the usual effect desired to restore a simple keratosis, mild epithelioma or a wart.

Having once experienced the very definite results of using his specimens he never loses the mental picture of its action, or rarely misjudges the requisite time of application to each patient. For the greater number of mild epithelial lesions, the author prefers one or two exposures near together, and then gives the patient a written statement of what to expect during the month following. If, however, more intensive treatment is necessary, then cumulative or successive attacks are better, and an interval of one or two weeks between treatment works out a better result. Thus, successive blows fall upon the disease, sustaining a long corrective action, rather than an intense and destructive one.

Any epithelioma less than one centimeter in thickness can be treated by radium which is not shielded by lead. The container or applicator should be covered by thin rubber sheeting (dental dam) and by several layers of gauze. If a recurrent cancer node or a lymph gland lies under healthy skin, then a lead shield must be interposed to prevent burning the skin, while penetrating rays are efficient below it. For ordinary purposes thin sheet lead, $\frac{1}{10}$ millimeter thick (thickness of thick writing paper) is adequate. This permits an hour exposure, with a specimen which without lead would give sharp dermatitis in one-third that time. A two-hour exposure with $\frac{2}{10}$ more lead will be more efficient in deeper growths. In pelvic recurrent cancer in the upper vaginal scar, the best results I have seen were from one hundred milligrammes or more in tubes, surrounded by $\frac{1}{10}$ millimeters thickness of lead for two hours. The same amount in a brass container, 2 mm. thick is equally efficient applied ten to twelve hours.

The best surface applicator now devised is one in which radium is mingled with the least possible amount of pulverized glass and fused at a very high temperature into an enamel on a metal button. By this way the maximum concentration is obtained and a surface of the diameter of a ten-cent piece can be enamelled with 25 mg. of radium, which would require a disk the diameter of a silver half dollar if made with the usual varnish, which is much more perishable. Such a concentration in a small disk has very great advantages. It permits a short application of ten minutes which justifies the physician in devoting that amount of time to concentrated thought in applying it with extreme care exactly as he wishes, instead of strapping it upon the patient, and finding in half an hour that it had slipped from its place, or been displaced by the patient. By its size, also, it permits exact application about the tongue and inside the mouth and other cavities. This is most essential in its difficult but effective use in leukoplakias. This small 25 mg. enamel button I regard as the finest working model for radium therapy. It is readily enveloped in rubber, thin lead and gauze, clamped by its small knob at the back of the button in the bite of a long clamp, and thrust into a narrow thin rubber bag which permits it to be pushed against the tonsils or far up in the vault of the vagina against a diseased cervix or cancerous scar, and there held with unrivalled precision during the needed exposure. Being carefully protected it is never soiled, but if it does become so, it can be safely washed without dissolving the radium from the enamel. In practice it is found that ten minutes' use of this concentrated enamel plaque equals thirty minutes of the same amount in a varnish plaque which must be of four or five times larger area. It has the added advantage also of being moved back and forth over irregular surfaces, as in nevus, or skin lesions, and evenly affecting the disease with no scarring or spotty results. The method of concentrating radium emanation into capillary glass tubes which can be inserted in thin metal needles and thrust into tumors for penetrating and cross-fire result, finds many uses and some advantage. Nevertheless, tubes of stiff thin celluloid have been successfully used by the author for twelve years, to contain two to five glass tubes of radium, each holding 25 mg., which he has pushed into stab wounds in tumors to cross-fire them in every direction. These superseded long experimentation with purified goosequills, which offer no resistance to the radium penetration. The celluloid tubes are very inexpensive, four inches long, smaller than a lead pencil, and are never used twice.

It will be evident to the reader that it is impossible for an amateur with only 10 mg. of radium to do effective work. He will only disappoint himself and his patient and bring disrepute on this important new field of surgical endeavor. It is fair to say also that no one without a previous varied and large surgical experience can do justice to comparisons between the efficiency of radium and of other well established destructive remedies. The use of this wonderworking agent should be left to those who have enough to study its effect and whose clinical opportunities enable them to select suitable cases for its use.

DEEP ROENTGENTHERAPY.

By HENRY SCHMITZ, A.M., M.D., F.A.C.S.

Roentgentherapy of today differs from that of yesterday as fundamentally as surgery of today differs from that of the era before Lister, Pasteur and Koch.

The introduction of the Coolidge tube, the development of the modern interrupterless transformer, as first devised by Snook, of Philadelphia, and lastly the replacement of the rheostatic control with the magnetic autotransformer control, have contributed immeasurably to the development, efficiency and efficacy of deep roentgentherapy.

The Coolidge tube possesses simplicity in operation, accuracy in penetration and duplication of results. The modern interrupterless step-up transformer with the autotransformer control gives us a constantly maintained voltage when tube current is increased.

The roentgentherapist should understand the principles involved in the physics of roentgenology. He should be well informed in general medicine; should understand the pathology of the disease that he is called upon to treat and should be familiar with the technical knowledge that is approved by the best authorities in the treatment of each particular disease. He should be familiar with the effects of the roentgen rays on the living cell. We can see at a glance that the mastery of these requirements is no child's play but means hard and continuous work, and should be associated with a deep sense of responsibility.[1]

THE COOLIDGE TUBE.

The great difficulty in the operation of the ordinary gas tube lies in the irregular supply of electrons and the impossibility of their accurate development. In therapy these obstacles are continuously a source of worry. For as the vacuum of the gas tube through the heating of the anticathode becomes lower and lower on account of the requirements of prolonged use, the rays given off proportionately decrease in their penetrating power. It could only partly be corrected by water-cooling devices, a frequent exchange of tubes and reducing the load of milliampèrage which necessitated a proportional prolongation of the time of application.

Wehnelt and Richardson had found that electrons also were emitted by hot metals. This led to a series of developments of the roentgen tube, beginning with Lilienfeld, in December, 1911, continuing with

[1] Pfahler, G. E.: Am. Jour. of Roentgenology, August, 1916, iii, 404.

Fürstenau, in April, 1912, and culminating with Coolidge, in December, 1913. This particular development of the roentgen tube has given to us the electron type of tube, as first presented in Germany by the Lilienfeld tube, and finally in this country by the Coolidge tube. These developments have been epoch-making, demonstrating as they did, for the first time, the possibility of transferring electricity through space without the interposition of ponderable matter. This may be said to be one of the most striking facts of modern science (see Fig. 29).

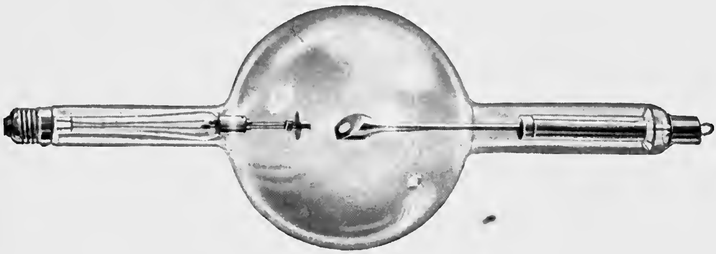


Fig. 29.—Coolidge tube.

For the proper operation of the Coolidge hot filament tube the highest possible vacuum must be attained, so there might be no source of electrons except from the hot filament. Thus the operator has perfect control of the number of available electrons by simply changing the auxiliary current heating the filament, an increase of this current raising the number of electrons, and *vice versa*, a decrease in the current lowering the number. The filament current in the tube cannot get increased after the supply of electrons is entirely utilized, no matter

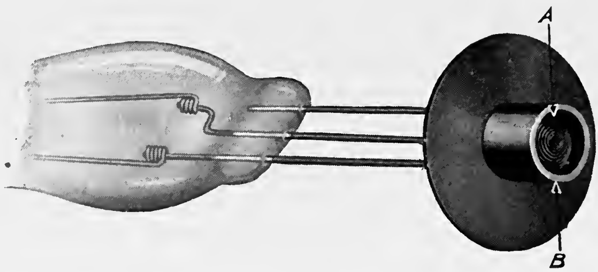


Fig. 30.—The anticathode or target of a Coolidge tube.

how much the voltage is raised. This maximum current is known as the saturation current. The Coolidge tube will give us accuracy of adjustment, stability of hardness, possibility of exact duplication of results, unlimited life, great range of flexibility, absence of inverse radiation and extremely large output.

The Coolidge tube consists of a tube exhausted to a pressure of not more than a few hundredths of a micron (a micron is 0.001 mm.), in which is supported the cathode so arranged that it may be heated electrically; an electrically conducted cylinder or ring connected to the heated cathode and so located with reference to it as to focus the cathode rays on the target and the anticathode or target, which functions as an anode.

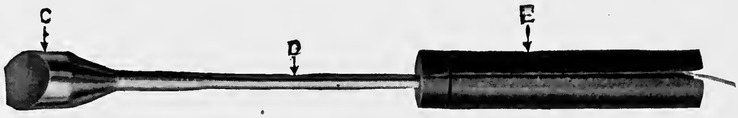


Fig. 31.—The filament of a Coolidge tube.

The filament (see *A*, Fig. 30) which forms the cathode consists of a flat, closely wound spiral of tungsten wire. By means of a rheostat the heating current may be varied from three to five ampères, giving a potential drop through the filament of from 4.2 to 10 volts, with a corresponding temperature variation of from 1700° to 2350° C.

Fig. 32.—The filament current transformer.

The focussing device consists of a cylindrical tube of molybdenum (see *B*, Fig. 30), mounted concentric with the tungsten filament and with its inner end projecting about 0.5 mm. beyond the plane of the latter. Besides acting as a focussing device it also presents any electron discharge from the back of the cathode.

The anticathode or target (Fig. 31), which also serves as an anode, consists of a single piece of wrought tungsten (C) attached to a molybdenum rod (D) and supported by a split iron tube (E).

The important characteristics of the Coolidge tube are: (1) No discharge current through the tube unless the filament is heated; (2) the amount of discharge current is determined primarily by the amount of current passed through the filament; (3) the penetrating power of the roentgen ray is determined by the voltage across the tube terminals; (4) the starting and running voltages are the same; (5) the allowable energy imput is determined by the size of the focal spot; (6) continuous operation is possible without change of characteristics; (7) the focal spot is fixed in position.

To simplify and render more accurate the operating of the Coolidge tube, some source of filament current is needed which gives a perfectly constant potential. A specially designed step-up transformer has been devised for this purpose (see Fig. 4), which is connected with the usual filament current controller. It is the function of the former to make it

Fig. 33.—The filament current transformer control.

possible to deliver to the filament constant current, even though the line voltage may fluctuate greatly and suddenly. The filament current transformer is retained merely to provide the necessary insulation between the filament circuit and the supply mains. The special constant potential transformer has no moving parts and no time lag. It allows the filament current to fluctuate less than 1 per cent., when the supply voltage varies 25 per cent. This means that it completely takes care of the ordinary fluctuations in the supply voltage, due to causes external to the roentgen-ray installations and of the sudden drop caused by the closing of the roentgen-ray switch as well.

Changes in the filament temperature may be effected by means of a dial switch (see Fig. 33), which controls a resistance connected in series with the primary of the filament current transformer. Each point of the dial, with the same tube, always means the same temperature, and hence the same milliampèrage. The higher the filament current the greater the milliampèrage. The higher the voltage backed up by the tube the higher the penetration.

THE TRANSFORMER.

The rapid development of modern roentgenology made it necessary to increase the capacity of the x-ray apparatus in order to meet the requirements of therapeutic irradiation as well as of radiographic and fluoroscopic practice.

These demands were met by the interrupterless step-up transformer. It was first introduced and made in 1907 by H. Clyde Snook, of Philadelphia (see Fig. 34.)

Fig. 34.—A modern interrupterless transformer.

The machine consists essentially of three parts: the motor, the high-tension transformer and the high-tension rectifier or commutator.

The interrupterless transformer makes use of the alternating current, which is the current furnished American cities by most of the commercial power plants. A rotating pole-changing switch rectifies the high potential alternating current from the secondary of the transformer. To secure perfect synchronism, which is essential for rectification, the motor is mounted on the same shaft as the rectifier and runs about 1500 revolutions per minute. The motor must be very carefully designed and constructed, otherwise it will cause trouble if there is any possibility of its running not absolutely in step or in synchronism with the current. The transformer is capable of an enormous output and easy control; there is no inverse current and no interrupter is needed.

The rectifying switch in the Snook apparatus is of the cross-arm type while other makes usually use the disk type.

The transformer changes voltage approximately in the ratio of the number of turns in the primary to the number of turns in the secondary, and changes current in the inverse ratio. Thus a particular roentgen-ray transformer might be wound with 500 turns in the secondary for each turn of primary, and it would be said to have a step-up ratio of 500. The secondary voltage would be 500 times the voltage in the primary and the secondary current $\frac{1}{500}$ of that in the primary.

Primary applied voltage.	Resultant high tension voltage.	Approximate spark gap, inches.
80	40	3
90	45	3½
100	50	4
110	55	4½
120	60	5
130	65	5½
140	70	6
150	75	6½
160	80	7
170	85	7½
180	90	8
190	95	8½
200	100	9
210	105	9½
220	110	10

A table of voltages that must be supplied and maintained at the primary terminals to give various high-tension voltages can easily be made in this case.

Such primary voltages can be secured from a line supply of 220 volts by proper controllers, either the rheostat or the autotransformer control (see Fig. 35). The former is an adjustable resistance used to consume a part of the line voltage and leave the proper voltage to be applied at the transformer.

The autotransformer control consists of a continuous coil of wire wound around an iron core with taps taken out to control buttons at proper intervals. If an alternating current be applied to the complete winding of such a coil there will be a voltage induced in any part of the winding, bearing the same relation to the applied voltage that the number of turns of this part of the winding bears to the number of turns in the whole coil. The ratio between the number of turns in the primary and secondary circuits is changed by setting the control lever on the various buttons. The autotransformer is used as a control device to reduce the line voltage to that which is applied to the interrupterless transformer primary. Therefore it is a step-down transformer and has fewer turns in the secondary circuit than in the primary. As the control handle is moved to higher readings more turns are cut into the secondary circuit and higher voltage is applied to the primary of the interrupterless transformer.

The use of a rheostat to control tube voltage has the disadvantage that slight variations in tube current result in serious changes in voltage. The voltage "regulation" under various loads of a rheostat controlled transformer is poor. Softening of a gas tube during exposure or fluctuation in the filament temperature of a Coolidge tube will lower the voltage 10 kv., or about an inch of spark gap. Hence there is a loss in penetration. Also, if there were a break in the Coolidge filament line

Fig. 35.—The control table with autotransformer and rheostat controls.

or polarity were wrong, so that no current flowed in the secondary circuit, the primary voltage would rise to that of the line, with considerable likelihood of sparking to the patient or causing damage to the apparatus.

The autotransformer control is of special value with the Coolidge tube, as in this tube the voltage and filament current are independently controlled; the voltage by the autotransformer and the high-tension current through the tube by adjustment of the temperature of the cathode filament. If the filament current is not entirely steady with a rheostat control the radiation would be reduced in quantity and be less penetrating, while with the autotransformer control the same change would result in an increase in quantity and also in penetration. Hence the cathode filament current controller and the autotransformer control are two instruments of precision which give us almost absolute control of penetration. It is simple and accurate and can be duplicated day after day.

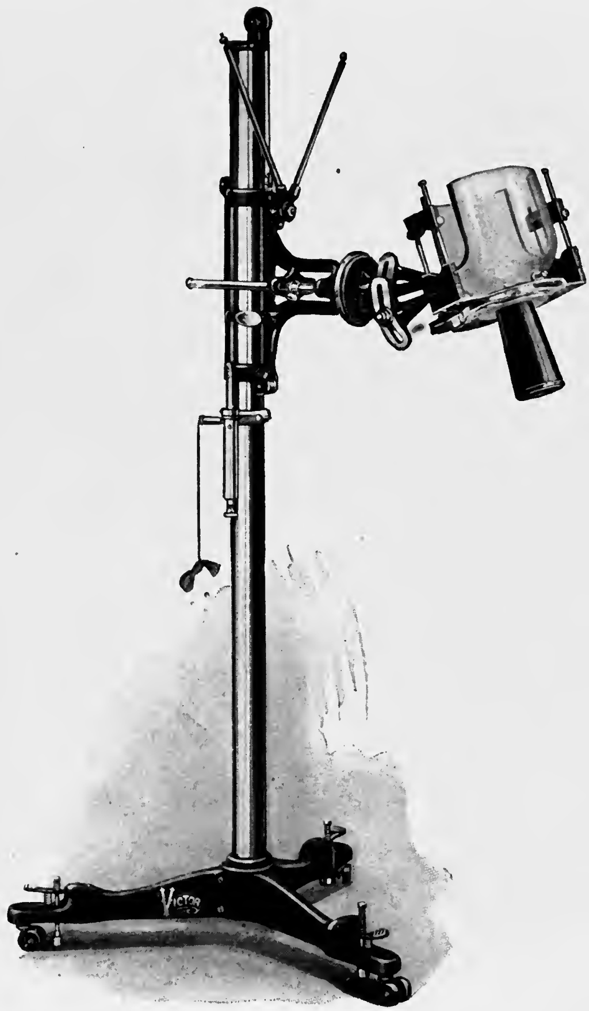


Fig. 36.—Tube stand.

It is important to note that in using the autotransformer control it is advisable to also throw in the rheostat control. If anything should go wrong with the former the latter will immediately take care of the changed current condition, so sparking of the patient, puncturing the tube or other accidents are effectually prevented. The patient also should be grounded. A wire screen netting is placed over the patient, for instance the lower extremities. It is weighted down by suspending a heavy object from either side. The wire is grounded to a water or waste pipe. Should a full spark strike the patient it is thus immediately dispersed down the grounded wire and the patient thus remains protected.

To recapitulate: Modern deep roentgentherapy requires for the source of the x-ray current an interrupterless transformer, an autotransformer control, a Coolidge tube with a medium focus and a transformer control for the cathode filament current.

Accessories.—A great variety of accessories also are necessary such as a tube stand, a treatment table, markers and so forth.

A very simple and practical tube stand is shown in Fig. 36. It is arranged so that the tube lies parallel to the axis of the carrier, though

Fig. 37.—A simple but practical treatment table.

it may be moved in any direction. The former position is necessary in suprapubic and neck treatments, especially when crossfiring must be used. It is advisable to ground the stand to a water pipe to prevent sparking of the patient.

The treatment table should be a wooden one, the top must be very carefully padded, so the patient can lie on it for any length of time. A common examining room table, as reproduced in Fig. 37, has been found very practical and gives great satisfaction.

The patient can be arranged in any position desired, as prone position, lithotomy position, extended neck position and left lateral.

The roentgen treatment room should be large and well ventilated. The transformer is preferably located in a separate room, so as to deaden its noise as much as possible. The switchboards are located in a small booth. The partition toward the patient should be lined with lead-sheeting of 0.3 mm. thickness. A window of leaded glass must be installed, so the patient may be continuously observed by the operators.

The patient must be protected by leaded rubber sheeting. An opening 3 inches square is cut in about the center which exposes the part of the patient to be treated. To obviate any error in applying the rays, it is necessary to map out the area to be treated into squares, usually of $1\frac{1}{2}$ inches. This is best done by using a skin ink composed as follows: ℞—Acidi pyrogallici 1.0, acetone 10.0, liq. ferri perchlor. fort. 2.0, sp. vini menth. ad 20.0; m. et s.: skin ink. The areas are crossed off with the same ink after a treatment, so errors are impossible. A standard to mark the squares should be used. The one for more superficial work should have 16 squares of 2 inches, and the one for very deep work 12 squares of $1\frac{1}{4}$ inches each. The smaller squares are needed to cut out the greatly dispersed peripheral rays in treating deeply located tumors. This precaution must be observed to avoid stimulation of the tissues by the weak peripheral rays.

The compression tube must be built so that it tapers down to a square of $1\frac{1}{2}$ inches or it may be of the ordinary cylinder type. Then a lead plate having the same diameter as the tube and a square of $1\frac{1}{4}$ inches in the center is placed on a given square. In this manner no portion of the body surface receives any rays except the area to be treated (see Fig. 44).

We also must employ means for determining the erythem dose for each Coolidge tube under exactly like conditions of application. This will be discussed in another paragraph.

Technic.—The radiation given off from a roentgen tube, *i. e.*, one backing up a 9-inch spark or activated by 100 kv., is nearly always of a heterogeneous character. It not only emits highly penetrating rays, but simultaneously a varying proportion of medium hard and soft rays. Half of the medium hard rays are absorbed within the upper 2 cm. of tissue beneath the skin, while one-half of the soft rays do not penetrate deeper than abour 7 or 8 mm. In deep roentgen-ray therapy it seems to be desirable to only use rays which are absorbed at the depth of the diseased organs or regions. Rays absorbed without this area would strike healthy tissue which is not desirable. If we could filter out these rays we would gain a distinct advantage. This can be attained by the interposition of a filter, usually made of aluminum. The questions arise: What has been done to a beam of *x*-rays on interposing a filter in its path? In what ways have its intensity and character been altered? The quantitative estimation of the absorption suffered by a beam of *x*-rays in its passage through a substance may be made by measuring the ionization caused by the beam initially and to trace the gradual diminution in this ionization as successive layers of the material in question are interposed between the beam and the ionization measure. The results would differ according to whether a soft, a medium or a hard tube is used.

With regard to the penetration of animal tissue by roentgen rays an extensive series of measurements were made in 1905 by Perthes, who found that the absorption by most of the tissues was extremely near that of water. He also determined the thickness of tissue required to reduce the intensity of roentgen rays by a certain amount as measured by a fluorescent screen and also the thickness of aluminum which produced the same reduction. From the values given in his monograph it appears that aluminum is from seven to ten times as effective an absorber of roentgen rays as tissues of about the same density as water. This is nearly three or four times as much as its density would suggest.

Guilleminot has made an elaborate study of the absorption of x-rays by determining the intensity of the rays after passing through various thicknesses of tissue; this was done for screened as well as unscreened rays.

Quality of rays.	Surface.	0.5 cm.	1 cm.	2 cm.	3 cm.	4 cm.	5 cm.	6 cm.	7 cm.	8 cm.
4 Benoist	Dose transmitted 100	65.0	43.0	22.0	13.0	8.0	5.2	3.8	2.6	1.8
5 Benoist	" 100	72.0	53.0	32.5	21.9	15.5	11.6	8.8	7.0	5.5
6 Benoist	" 100	78.0	63.0	44.0	33.0	26.0	21.0	17.2	14.4	12.0
7 Benoist	" 100	81.0	68.0	50.0	39.0	32.0	26.5	22.8	19.7	17.2
8 Benoist	" 100	83.2	69.9	52.7	42.0	34.8	29.5	25.5	22.3	19.6
8 Benoist filter 1 mm. Al.	" 100	86.5	76.2	61.1	50.6	43.0	37.3	32.6	28.5	25.4
8 Benoist 2 mm. Al.	" 100	89.2	80.4	67.0	57.1	49.4	43.3	38.2	33.8	30.1
8 Benoist 3 mm. Al.	" 100	91.0	83.5	71.8	61.8	54.5	48.0	42.5	37.8	34.8
8 Benoist 4 mm. Al.	" 100	92.8	86.0	74.5	65.4	57.8	51.3	45.7	41.0	37.0
8 Benoist 5 mm. Al.	" 100	95.0	87.0	76.1	67.2	60.0	53.8	48.5	44.0	40.2

A variety of substances may be used when it is desired to screen a beam of roentgen rays—that is to say, to cut off its softer components. Salmond has made a comparison of the efficacy of different screens commonly used.

Alumimum. mm.	Pure paper. mm.	Tanned leather. mm.	Chamois leather. mm.	Felt. mm.
0.5	3	3	10	13
1.0	7	7	18	30
2.0	13	13	35	67
3.0	17	16	59	97

Porter and Christen have shown that in order to apply a maximum intensity of rays at a depth d, that particular radiation should be chosen which is diminished to one-half of its intensity by this thickness of tissue.

Thus the interposition of a proper filter arrests all the rays that would otherwise become absorbed in the skin and healthy structures lying in the path of the rays between the growth to be treated and the source of the rays. However the erythem dose of filtered rays is of a different intensity than that of unfiltered rays. If a pastille placed above the filter and at a half distance from the focus to the skin surface shows an intensity of 6 E. within ten minutes by a given current, the same pastille will record only one E., if placed on the skin beneath a filter of 3 mm. if the focal distance is 11 inches. Therefore the time period of the application of a filtered roentgen ray may be safely extended without any corresponding injury to the skin.

These considerations enable us to select that particular radiation necessary in the treatment of deep-seated lesions. For instance let us assume we were treating a carcinoma of the left ovary. The organ lies on an average 8 cm. beneath the skin surface. Hence we must select

FIG. 38.—Wehnelt radiometer.

a ray which becomes absorbed by one-half at a depth of 4 cm. Referring to the table of Guilleminot, we see at a glance that a tube must be used of a hardness of 8 Benoist and an aluminum filter of 3 mm. Again we intend to treat a breast cancer confined entirely to the organ.

FIG. 39.—Heinz Bauer Qualimeter.

The radiation is applied as a prophylactic measure. Anteriorly the ray should penetrate the chest wall, which is about 4 cm. Over the sternum we wish to penetrate the mediastinum, which is 10 cm.;

posteriorly we propose to treat the lymphatic structure, including the chest wall, which measures on an average 3 or 4 cm. The problem would be solved as follows: Anterior chest wall tube 7 Benoist, 2 mm. aluminum filter; sternum tube 8 Benoist, 4 mm. aluminum filter; laterally and posteriorly tube 8 Benoist, 2 mm. aluminum filter.

The multiple small fields and cross-fire method described has a great many disadvantages: the penetration of the rays is low, and the quality heterogeneous. The higher the voltage of the current the shorter the wave length of the electrons will be and the more penetrating or harder the rays must be. The quantity of the hard rays is also much larger than those obtained from a current of lower voltage. We are conducting experiments with a coil that furnishes current up to 180,000 volts. The tube is charged with 3 to 5 milliampères. The arms of the tubes as at present built must be lengthened to about 20 inches to reduce the danger of puncturing. Provision, also, must be made to cool the tubes either by water or oil. The focal distance has been increased to 24 inches. The metal filters consist of aluminum 18 mm. thick or pure copper 1 mm. thick. The compression tube has a diameter of 9 inches at the base. One field 9 inches in diameter over the pubic region is exposed to the rays for one consecutive hour and another field of the same diameter over the sacrum and buttocks for thirty to forty-five minutes. The difference in intensity of the rays between the skin surface and the depth is very small and almost negligible, proving the homogeneous quality of the rays.

The next question to decide is: How do we determine the penetrability of the radiation? Various methods are in use: The radiometers of Walter, Benoist, Wehnelt and Bauer. I have used the Wehnelt and Bauer which are reproduced in Figs. 38 and 39.

The Wehnelt radiometer is provided with a wedge-shaped aluminum strip, and along this a flat silver strip, both of which can be moved by means of a ratchet over a brass plate provided with a thin slit. The apparatus is adjusted until both strips show the same brightness on a fluorescent screen. A scale denotes the permeability of the activated tube.

The Bauer qualimeter is connected by a wire to the negative terminal of the coil or cathode of the tube. It is a static electrometer and condenser which indicates automatically the potential of the cathode, and hence the quality of the radiation. We may say that each division represents the energy of ten kilowatts. Hence if the Heinz Bauer instrument indicates at 9, we assume that the tube is charged with 90 to 100 kilovolts.

The comparative value of the instruments most frequently used is as follows:

Usual termination.	Very soft.			Soft.	Medium.			Hard.	Very hard.	
Bauer	1.0	2	3	4	5	6	7	8	9	10
Wehnelt	1.5	3	4.5	6	7.5	9	10.5	12	13.5	15
Walter	1	1–2	2–3	3–4	4–5	5–6	6–7	7–8		
Benoist	1	2	3	4	5	6	7	8	9	10

The method of estimation of dosage depends on the determination of the erythem dose. An erythem dose, *i. e.*, one E, is one which causes a slight erythema and loss of hair to appear on the skin fourteen days following the application. It is apparent that the application to a given area should not be repeated before this time-period has passed.

The estimation of an erythem dose depends on the change the *x*-rays produce on a disk of barium platinum cyanide, the green color changing to a brown. By experiment the exact tint was found which

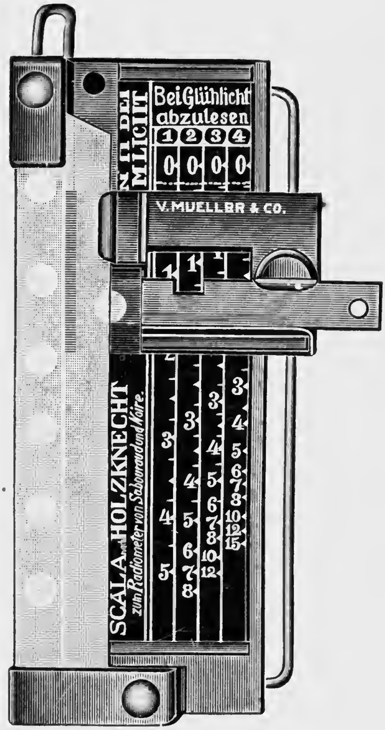


Fig. 40.—Holzknecht quantimeter.

the pastilles assumed after exposure to an erythem dose. Holzknecht has devised a color scale. The pastille is compared with an unexposed pastille of the same material arranged under a celluloid film of red-brown color, increasing gradually in intensity. By moving the exposed pastille along this film, the discoloration can be measured, 5H equal 10 x or an erythem dose. Another instrument based on the same principle as Holzknecht's radiometer and frequently employed is the quantimeter of Hampson, shown in Fig. 41.

The methods of measuring quality and quantity of rays as enumerated are not very exacting and rather liable to errors, because they are dependent on color determination. This is liable to cause subjective errors on account of individual differences in judging color changes, varying light conditions and differences arising in the tint of the tablets if exposed to radiation, and sunlight.

The only correct and scientific method must be based on the ionization power of the rays. Such instruments are known as ionization meters. They consist of an electrometer to which an ionization chamber is attached. The apparatus enables one to determine the exact amount of electrostatic units emanating from an activated roentgen tube within a known time period. The ionization chamber is constructed so it may be inserted into the vagina or the rectum. The exact number of electrostatic units of roentgen rays can thus be determined that reach the posterior pelvic wall in the treatment of pelvic carcinomata, while the exact surface dosage is obtained by placing the ionization chamber upon the exposed skin surface. Kroenig and

Fig. 41.—Hampson's quantimeter.

Friedrich have gauged the skin dose as 170 e, the cancer dose as 150 e and the ovarian dose as 33 e. The skin dose causes an erythema of the first degree. The carcinoma dose results in a visible and palpable decrease of the growth. The ovarian dose brings about amenorrhea, due to a degeneration of the ova and follicles by the rays.

The quantity of roentgen rays received by a given object depends on (1) the quantity of x-rays generated; (2) the quality of the tube radiation; (3) the distance between the focus and the object; (4) the time of exposure; (5) the sensitiveness of the object.

The quantity of the radiation is determined by the filament current, the voltage and the ampèrage, which also give us the quality. Both are subjected to the determination of the erythem dosage, which gives us the time duration. The latter varies according to the distance of the focus from the skin. Distance has a great influence, because the intensity of roentgen rays diminishes inversely as the square of the distance increases. If the focal spot is 40 cm. from the skin surface it requires four times as many minutes to obtain an erythem dose as a tube exposed at a focal distance of 20 cm.

The Biological Action of the Rays.—A study of the biological reaction of tissues to radiation enables us to correctly interpret the therapeutic value of the latter and assists us in the choice of the quality and quantity of rays to be employed. Since the effect of the action of rays, whether the source is radium or a roentgen tube, is not only local but also general, *i. e.*, systemic, a correct interpretation of the systemic reaction to the rays is very necessary. The latter enables us to formulate exact indications and contra-indications for the remedial use of radiations. Not only that; they also will materially aid us in the prognosis of radiation treatment.

Some of the earliest observations of the changes occurring in malignant tumor by roentgen-ray applications were reported by Clunet in 1910, who divided the changes seen in squamous-cell cancer treated with roentgen rays into five successive phases: (1) The latent phase; (2) development of giant cells; (3) keratinization; (4) disintegration and phagocytosis; (5) formation of connective tissue. The latent phase varies from six to fifteen days. During this time no changes in the cells are seen. In the second phase we see the formation of giant cells characterized by an enlargement of all parts of the cells, which may be increased in diameter as much as two or three times. Atypical mitoses are increased in number. The nuclei appear much enlarged and chromophile. During the third phase irregular forms of a pseudoparasitic character appear within the cells. Keratinization is seen in the protoplasm as well as the nuclei. The protoplasm becomes granular, often exhibiting vacuolation. The granules gradually are fused together into one mass of keratin. The nucleus may show karyorrhexis, diffusion into the protoplasm and granulation. At this time also a round-cell infiltration and active proliferation of fibroblasts in the stroma become very marked. Macrophages and microphages appear, evidently to devour the degenerated cells and cell debris. In the final phase regeneration is completed by a connective-tissue formation. All these changes are identical with those occurring in tissues irradiated with radium rays (see Fig. 42).

If, after some time, a portion of the scar be examined microscopically, epithelial cells may be seen, some representing giant cells, others degeneration of the protoplasm and still others abnormal stages of nuclei. They are probably dormant or in a kind of lethargic condition. If the treatment is not continued they may give rise to recurrences.

Sarcoma cells exhibit a somewhat similar transition; however, the latent phase is very much shorter, being only one or two days.

The changes occurring in cells by roentgenization are identical with those seen after applications of radium rays. The response to radiation by the cells may be best expressed by the law of Bergonié and Tribondeau, which has equal importance for both radiations: "Immature cells, and cells in an active state of division are more sensitive to rays than are cells which have already acquired their fixed adult morphological or physiological characters." Very rapidly growing cells are the most affected of any by radiations. However, different rays give rise to quite different effects upon one and the same cell. They have a "differential" action. Thus the action on tissues of soft, medium and hard roentgen rays differs as does also that of the Alpha, Beta and Gamma rays of radio-active substances. A careful distinction should

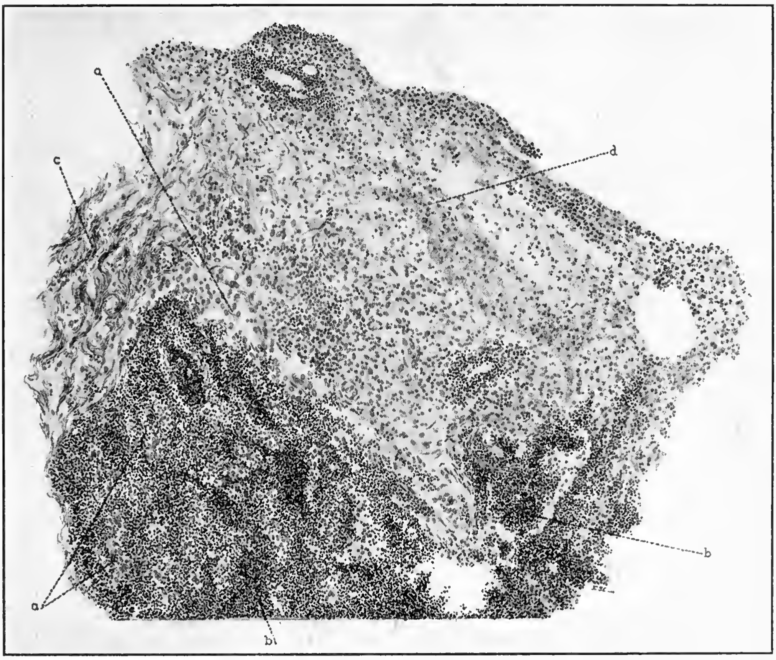


FIG. 42.—Effect of roentgen rays on cancer tissue. Mr. M., Augustana Hospital, No. 42283. Carcinoma of neck involving muscles. Tissue removed March 30, 1915. Low power magnification. *a*, carcinoma cells; *b*, leukocytic cells; *c*, connective-tissue fibrils; *d*, lymphocytic infiltration.

be made between the "differential" action which different rays have upon the same variety of cell, and the "selective" action which the same kind of radiation has upon the many different varieties of cells.

The degree of selective absorption of rays by living cells depends on the particular phase of its life cycle, their species, as well as the age of the host whom the cells inhabit. Cell elements which are embryonal or undifferentiated are destroyed by a radiation which would only cause a slight reaction in the surrounding mature or highly differentiated cells. The basal cells of the epidermis and hair follicles, lymphoid cells, sex cells, as ova and spermatozoa, are readily killed by a quantity of rays which would leave intact the surrounding and neighboring mature cells.

Selective absorption also depends on the elementary variety or species of the cell, whether epithelial, connective tissue or endothelial, and on the different varieties within each species. Normal connective-tissue cells are less receptive than normal epithelial cells. Epithelial cells of the basal layer of the skin are less sensitive than those of the papillæ of the hair follicles. They are different kinds of the same species. Lastly the tissues of a child are much more easily altered by radiation than corresponding tissue elements in the adult.

The observations made on normal cells apply with equal force to abnormal cells and tissues, neoplastic as well as inflammatory.

Remarkable examples of radiosensitive tumors are ectodermal and basal-celled epitheliomata derived from the basal-celled layers of the epidermis, lymphadenomata originating from embryonal lymph cells, sarcomata derived from embryonal connective-tissue cells, and in which the connective-tissue fibrillæ, cartilagenous and osseous tissues, have undergone resorption, fibromata in which fibroblasts are present in large numbers and do not develop into highly differentiated adult cells and connective-tissue fibers.

On the other hand, squamous-celled epitheliomata, fibrosarcomata, chondrosarcomata, osteosarcomata and fibromata in which atrophic fibroblasts and abundant fibrous tissue have been retained are very refractory to radiation.

The action of roentgen rays on neoplastic cells is of an impeding, destructive and evolutional character. The radiation arrests the growth of the tumors before it destroys them or renders them harmless by an evolutional process or metaplasia. Arrest of growth results from a cessation of the function of mytosis or genoceptor. Destruction of tumor cells is either a direct or an indirect process. In the direct form the tumor cells undergo necrobiosis. The cytoplasm and nucleus disintegrate, the cells are absorbed by phagocytosis. In the indirect destruction a metamorphosis of the tumor cells precedes absorption. This consists in a hypertrophy of the cells, enlargement of the nucleus, nucleolus and even centrosomes, so they appear like pseudoparasites and achromatism, vacuolation and granulation of protoplasm.

The evolutional influence of roentgen rays on tumor cells is evidenced by a retrogression or stimulation of the embryonic tumor cells so they develop to maturity. To understand this process we must have a clear conception of the formation, growth and function of a cancer cell. Tumor formation deprives the cells of their normal functions. They become "strangers" to themselves and to the mature normal cells from whence they originate. The growth of tumor cells is not only the result of a proliferation of a single embryonal cell group but also depends on a retrogression or metamorphosis of normal mature cells to an embryonal phase after they have become included into the cancer tumor. By a process of evolution the embryonic abnormal cell is stimulated to grow and developed into a mature, highly differentiated normal cell, thus becoming benign.

The action of roentgen rays on inflammatory tissues depends upon two phenomena: (1) The destruction by the rays of the anatomical elements, modified by inflammation; (2) the absorption of the degenerated tissue by phagocytes and its replacement by scar tissue.

This statement would presuppose that inflammatory products are more readily acted upon by the rays than normal tissues. This, indeed, is borne out by clinical observation. However, the reaction to radiations of inflammatory tissues differs, depending upon the underlying bacterial cause. Thus, simple inflammatory glands are quickly influenced by a few exposures—however, suppurating glands are not amenable to radiation treatment. Lymphadenomatous glands are less quickly acted upon, but they invariably diminish in size after a thorough exposure. Tuberculous glands are less readily affected. It requires a large number of exposures to induce retrogressive changes, but ultimately they also slowly respond to radiation treatment.

The employment of radiations in any form leads to a constitutional reaction which varies in the time of onset according to dosage and character of rays, the type and location of the tumor or tissue and the systemic condition of the patient. The constitutional reaction results from the changes occurring in the blood by the action of the radiation and from the degeneration set up in the growth by the rays which leads to an absorption of protein ferments into the circulation of the patient.

Some patients possess a marked idiosyncrasy in the sense that the same dose of radiation will provoke a reaction, the degree of which varies with the individual. Dosage is a complex quantity and includes the quantity and quality of radiation, the distance of the focus of the tube from the body surface, the area over which the rays are spread, the nature of the rays selected, the filter used, and the kind of tissue to which they are applied. In describing and comparing results obtained we should always state the size of tube, the hardness, the milliampèrage, the focal distance, the filter, the size and number of each field or portals of entrance and the time duration of the treatment. We also must give an exact statement of the type and size of growth, its extent and the formation of glandular and distant metastases. Finally, all general constitutional signs must be stated as pulse-rate, temperature, general nutrition of the patient, whether the disease has rendered the patient quite ill and moribund, a correct urinalysis and a complete examination of the blood, including a differential white count, and pulse and blood-pressure. These observations should be made and recorded before treatment is begun. They should be repeated at daily intervals until such a time that they have returned to normal or that their permanent existence is unquestionable. The patient must again be subjected to the same routine examinations at each subsequent course. It is only in this way that we are able to correctly interpret the constitutional reaction and the efficacy of the treatment as regards the local diseased conditions and the general state of health of the patient. The pulse-rate gives us valuable information about the influence of the disease on the general condition of the patient. A rapid pulse is usually associated with an advanced cachexia or complicating infection. A rise in temperature indicates either a complicating infection or extensive destruction, necrosis and absorption of tumor debris. Abnormal constituents in the urine may mean organic kidney disease or secondary disturbances in the kidney set up by the influence of the tumor on the general constitution. Increase in the total nitrogen and purin base output is a direct result of radiation. Low percentage of hemoglobin, decrease in the number of erythrocytes and leukocytosis, with an increase of neutrophiles, may indicate a secondary anemia due to hemorrhage or cachexia, an active infectious process, and so forth. If all of these signs are absent the general condition of the patient must be termed good. If one or all are present they either indicate complications of the underlying disease or constitutional reaction from the radiation treatment. It is clear that we could not determine the presence of the latter if a painstaking examination did not precede each course of treatment.

Attention to the changes occurring in the blood by the action of radiation was first directed by Senn in 1903 in cases of leukemia. This observation led to numerous investigations, the outstanding feature of which was that a diminution in the total number of white cells results from the general effect of prolonged exposure to *x*-rays. The lymphocytes appear to be the most sensitive of the white cells, the number of which gradually decreases, while there seems to be an initial increase in the polymorphonuclear leukocytes. Chronic exposure of roentgenologists to the ray almost invariably leads to a decrease in the number of erythrocytes, without apparently affecting their general health. (Aubertin.)

Stevens in an extensive study on the blood in cancer under roentgentherapy derives the following conclusions: Roentgen rays, applied in repeated large doses, with deep penetration, profoundly affect the erythrocytes of human beings. For the first few days the lymphocytes are suppressed or destroyed by large doses of roentgen rays in the treatment of cancer. In favorable cases this is followed by a reaction with lymphocytosis between the third to the seventh days, which may continue almost uninterruptedly till the fourteenth day, or it may stop shortly after the seventh day and reappear more strongly and persistently on or about the fourteenth day. There is a strong resemblance between the curves of these lymphocytic reactions and those which constitute the opsonic index. The treatment should probably not be repeated until the reaction is over. The repetition of the dose should probably by governed by the reactions in the blood as well as in the skin, the former being much more sensitive than the latter. In some cases of cancer the roentgen rays tend to stimulate a general immunity if lymphocytosis is an indication of immunity. The action of roentgen rays in cancer, therefore, would appear to be twofold: local by its destruction of disease cells and general by stimulating lymphocytosis, and, consequently, resistance.

The clinical symptoms of the systemic reaction resemble an acute intoxication. They include extreme prostration, together with such gastro-intestinal symptoms as vomiting, diarrhea and anorexia, an increase in the pulse-rate and a rise in temperature. At the same time there is observed an increase in the excretion of uric acid, the total nitrogen and purin bases in the urine and also a marked increase in the non-protein nitrogen in the blood. All observers agree that the intoxication results from the destruction of tissue cells by the ray, particularly tumor cells, on account of the much increased selective absorption the latter possess in comparison to normal mature cells. The liberated protein ferments are absorbed into the circulation, causing a temporary hyperleukocytosis. The decrease in the number of lymphocytes is the result of a directly destructive process of the rays. As the blood circulates through the area under treatment the highly selective absorption of rays by the lymphocytes causes their destruction. The tissue injury may be so great and tissue catabolism so increased that the intoxication may become so severe as to cause death.

The nausea and vomiting so often observed in patients during the time of treatment result from the effects of the rays on the vasomotor system and the inhalation of gases, especially ozone, liberated by the high-tension currents in the treatment room. They are transitory and immediately subside after the treatment.

It is clear that an organism not weakened by the tumor disease is much more able to resist the toxic action of rays and much more capable to respond to the sudden demand on the organism for the complete disintegration and excretion of a large amount of the products of tissue breakdown. It is also a fact that treatments should not be repeated until the organism is entirely freed from the intoxication.

TREATMENT.

Having discussed the source of the ray, the technic of the therapeutic application, the degenerative changes brought about in normal and abnormal tissue and the effect of the radiation on the constitution of the patient, it now behooves us to discuss the employment of roentgen rays in surgical diseases. The latter may be divided into several divisions:

1. Malignant growths.
2. Benign growths.
3. Inflammatory diseases.
4. Blood diseases.

1. **Malignant Growths.**—Success in cancer therapy can only be attained by the total eradication or degeneration of all cancer cells in the host attacked by the disease. Whether the means employed are surgical or radiological does not matter. The danger in the treatment of cancer with surgery consists in the fact that we frequently cannot totally remove all of the cancer tumor and the latter now begins to grow with an increased rapidity due to a rapid autotransplantation of tumor cells caused by an incomplete procedure. The danger in the

treatment of cancer with radioactive substances consists in the fact that we cannot rapidly destroy all the pathologic cells. We stimulate proliferation. An accelerated proliferation increases the danger of the formation of metastases.

Complete surgical eradication of a neoplasm is the best available means to prolong the life of the patient. But to be effective it must be early. An anatomical cure can be obtained only if absolutely all cancer cells have been removed from the body of the bearer. It is only rarely that such an ideal result is obtained. Otherwise recurrence could not be the rule as statistics and clinical observations clearly prove. Surgical eradication is in most cases defective: (1) Because the whole growth is not removed and the roots or seeds are left behind; (2) because these vestiges develop with an increased rapidity when the primary tumor is removed; (3) because operation favors the formation of distant embolism, sources of incurable metastases. Surgery removes but cannot modify cancer cells or render them harmless. However, as we have shown above, roentgen rays can annihilate that power of boundless cellular activity which constitutes the secret, the malignancy of cancer. It is necessary to concentrate a sufficient quantity of penetrating rays into the depth of the body to kill the cancer cells without seriously impairing the skin and the overlying and surrounding normal organs and tissues. Deep roentgentherapy correctly applied enables one to do so. It is clear that results and statistics in cancer therapy would be very much improved by a combination of surgery and radiation treatment. It also follows that results of surgical trauma of cancer cells would be rendered negligible if the cells were rendered harmless before the patient is subjected to operation. Indeed the method of treatment of cancer tumor at our clinic during the past three years has been carried out along this line. Namely, we first irradiate the growth, the neighboring regions and the regional lymph gland groups, next we operate early and radically remove all that is visible and palpable, and lastly we again irradiate the former seat of the tumor, the neighboring tissues and the regional lymph gland groups. Wherever it is possible we combine radium with roentgen therapy either inserting the radium tubes through the natural channels into the organs or carrying radium needles through small openings in the skin into the invaded tissues and tumor by specially constructed trochars.

Success in roentgen-ray therapy can only be attained by adhering most rigidly and minutely to a systematic technic. This includes the correct determination of the degree of penetration of the ray, the amount necessary to degenerate the cancer cells and the proper distribution of the fields to be radiated. Figs. 43 to 46 show at a glance the methods to be followed.

The degree of penetration is determined by referring to the table of Guilleminot given on page 245. The amount of roentgen rays necessary to degenerate a cancer in the depth of the abdominal cavity has been accurately determined by Bumm who found that from 3 to 5 E of massive, filtered roentgen rays are necessary to destroy a carcinoma within 2 cm. from the body surface. However, it takes from 30 to 50 E to obtain the same result in the depth of the pelvis, which is about 10 cm. beneath the compression cylinder if the latter is pressed down onto the abdominal organs. The tube must always be directed toward the cervix, so that the application of 3 E through each one of the fields

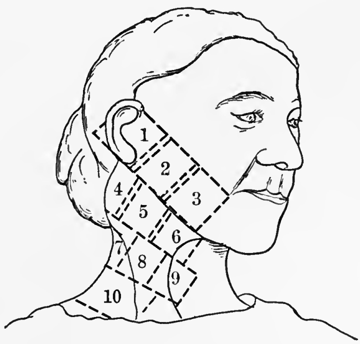


Fig. 43.—Arrangement of fields in treating cancer of the oral cavity, throat and neck.

1 to 7 and 16 to 20 in Figs. 17 and 18 would give an amount of twelve times 3 E, *i. e.*, 36 E or 360×. Thus by "cross-firing" the desired result would be attained. Four such courses are repeated every two or three weeks to make doubly sure that the disease has been arrested. If surgical removal is advisable it is instituted soon after the reaction following the first course subsides, *i. e.*, within two or three days.

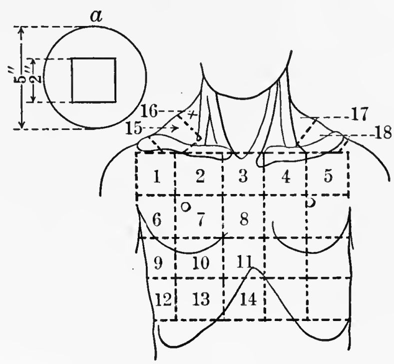


Fig. 44.—Arrangement of fields on anterior chest wall in cancer of chest.

The method of treatment just described and the schematic drawings of the fields of entrance of the various regions of the body will enable anyone to pursue the plan of treatment instituted in our clinic.

The local result of successful ray treatment is arrest and gradual disappearance of the growth, the healing and epithelialization of necrotic ulcers and cessation of discharge and bleeding and in favorable instances subsidence of pain. Constitutional symptoms improve proportionately Thus appetite, sleep, weight and strength return; pulse and temperature become normal, so that subjectively the patient appears to be normal.

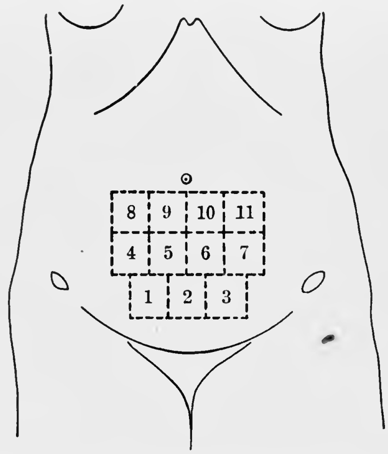


FIG. 45.—Arrangement of fields in suprapubic regions in cancer of the pelvic organs.

How long should the radiation be continued? If an improvement in the local and constitutional condition does not ensue within six to eight weeks the treatment should be discontinued as useless. On the other hand, should the local and constitutional signs show amelioration or cessation the patient must be instructed to return every four weeks

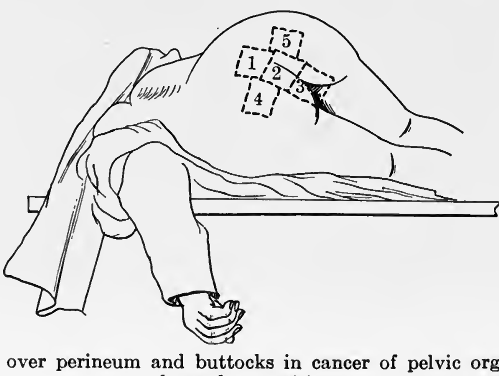


FIG. 46.—Fields over perineum and buttocks in cancer of pelvic organs. Patient in knee-chest position.

for examination. On the slightest sign of a recurrence, either locally or symptomatically, another course of radiation must be instituted. If after a time period of two years the patient has remained apparently well after most painstaking examinations the interval between reëxaminations may be extended to three months. The patient should be instructed to return sooner if any disturbance appears. After five years, during which time the patient has remained free of any recurrence, the patient can be discharged as well, although careful reëxaminations made every six months should be insisted upon for some time.

In conclusion, we must always realize that success in cancer treatment can only be attained by the total eradication or degeneration of all cancer cells present in the body of a victim of the disease. This principle must be observed if we are to expect results whether the means chosen are surgical or radiological. The danger in the treatment of cancer with surgery consists in the fact that we cannot always remove all tumor tissue. The vestiges left now grow with an increased rapidity and by autotransplantation cause secondary growths in different parts of the body. The danger in the treatment of cancer with radio-active substances consists in the fact that proliferation is enormously stimulated if we cannot rapidly destroy all the pathological cells. An accelerated proliferation increases the danger of the formation of metastases.

Sarcoma.—The treatment of sarcomata with the roentgen ray depends chiefly on the histological structure of the growth. A spindle-celled sarcoma is very refractory to the action of any ray while a round-celled growth responds very readily. "It melts away like snow in the sun" is a very apt comparison for the reaction. Sarcomata containing a large amount of adult connective tissue, cartilage, osseous tissue, muscle or nerve structure, do not react nearly as readily as a growth composed chiefly of embryonic structures.

We invariably combine roentgentherapy with the administration of Coley's vaccine.

The principles of the application of the massive and intensive roentgen ray are the same in this class of growths as those observed for carcinoma. However the prognosis is different. If a patient suffering with a malignant connective-tissue tumor has remained well for one year, he may be considered cured.

2. **Benign Growths.**—The object of radiation treatment in benign growths is to render them symptomless. This may necessitate either the arrest of some abnormal function caused in the organ invaded by the tumor or the reduction in size of the growth if the latter causes an obstruction.

Benign growths of the following organs have been successfully subjected to roentgen-ray treatment: Diseases and enlargements of the thyroid gland complicated with hyperthyroidism, enlargement of the thymus, hypertrophy and benign tumors of the prostatic gland in the male accompanied with residual urine, and myomata uteri causing profuse uterine hemorrhages.

The region above the thyroid and thymus glands is divided into four squares of 2 inch each, or if the gland is very large six such fields are marked off. To each field 3 E of filtered rays are applied, the technic not differing from that employed in cancer. At the end of two weeks a comparison in the triad of symptoms and the circumference of the neck is made with that existing at the beginning of the treatment. The usual general treatment must be observed, *i. e.*, rest, diet and internal medication. Such radiation treatment is indicated whenever the patient suffering from hyperthyroidism is a poor surgical risk or refuses surgical treatment. Radiations should be continued until the patient is rendered symptomless. The treatment of enlarged thymus glands is conducted according to the one recommended for the thyroid gland.

Enlargements of the prostatic gland, that cannot safely be subjected to surgical enucleation, are treated by applying the roentgen rays through the perineum and the suprapubic route, the same method as in treating cancer of the uterus in the female. If radium is available it should be used in conjunction with the roentgen ray. It is best to insert radium needles into each lobe of the prostate. If relief is not immediate it is deemed advisable to perform a suprapubic cystotomy under local anesthesia. It is of course understood that surgery must be resorted to unless urgent contra-indications forbid it.

The success of roentgen-ray treatment of myomata uteri depends on an arrest of ovulation. The following indications must be observed: The tumor must not cause pressure symptoms. It must not be complicated by another pathological condition in the pelvis. It should not be larger than a newborn infant's head. It must not be located in the cervix or be pedunculated or subserous or submucous. The patient should be thirty-five years or older. However, if the patient is a poor surgical risk she should be subjected to radiation treatment even in the presence of one or all of these conditions.

The rays are applied to seven portals of entrance in the suprapubic region as advised for treatment of carcinoma uteri. A course must be given soon after the cessation of a menstrual period and should be repeated every four weeks until amenorrhea is permanent.

At times menstruation recurs. If it is normal it need not cause alarm. If the bleeding becomes profuse another course of radiation treatment is given. Such recurrences result from a reëstablishment of ovulation. The younger the subject is the more probable the likelihood that menstruation reappears.

Reduction in the size of the tumor takes place with the progressive senile atrophy of the genital organs. Such tumors may gradually and completely disappear. Should the myoma contain a marked admixture of highly differentiated connective tissue and connective-tissue fibers a reduction in size or total disappearance of the growth is unlikely. A symptomless myoma uteri does not necessitate treatment. Therefore, persistence of the growth is not an indication for any further treatment.

3. **Inflammatory Diseases.**—Inflammatory hypertrophies have been successfully treated by roentgen rays. It is not necessary to describe the technic. The fields of entrance are outlined exactly the same as employed in the treatment of cancer. Though the treatment is individualized for each patient yet the fields are always outlined in the same manner. Thus neglect or inaccuracy are impossible.

Inflammatory diseases thus treated are chronic infections and hypertrophy of glands, tuberculous adenitis, tuberculous diseases of the breast, the skin, the peritoneum, the abdominal and pelvic organs, fibrosis uteri accompanied by menorrhagia, hemorrhagic myopathies, pseudoleukemia, although the latter is probably a lymphosarcoma and so forth.

The tuberculous process must be free of cheesy degeneration. Otherwise the latter should be aspirated before radiation treatment is begun. Therapeutic results obtained in such tuberculous diseases are better than those of surgery.

Radiation treatment in tuberculous and chronic inflammatory disease is repeated every two or three weeks until a subsidence of all local signs of the disease is attained. Should the process not yield to the treatment within six to eight weeks further treatment is inadvisable. Recurrences are again subjected to another course or courses of roentgen-ray treatment.

The contra-indications of roentgen therapy in bleeding uteri are the same as for bleeding myomata uteri. However, it is imperative that malignancy must be ruled out. In doubt hysterectomy is the only correct procedure. It must, however, be preceded and followed by irradiation treatment.

The event of amenorrhea means successful treatment. Recurrences of profuse menses necessitate additional courses of roentgen-ray treatment, though success is certain if indications are strictly adhered to. Failure in arresting hemorrhage means existence of complications which escaped our examination findings.

Roentgen treatment of Hodgkin's disease constitutes the best palliative method we possess. It surpasses in efficacy any other therapeutic procedure. The treatment to be successful must be extended over all of the glandular organs, and especially the mediastinum and spleen. Disappearance of the enlarged lymph nodes indicates success of therapy and the treatments should then be interrupted. Reappearance of swellings necessitates further treatment.

We also must mention the rather frequent occurrence of keloid formation in scar tissue which is very troublesome in some and objectionable from a cosmetic standpoint in others. Radiation pushed to the extent of causing a superficial burn will be followed by a disappearance of the keloid.

In chronic malaria roentgen rays applied to the enlarged liver and spleen will cause a diminution in size. However, the improvement is a symptomatic one only as the schizomycetes remain undisturbed.

4. **Blood Diseases.**—Diseases of the blood offer a thankful field for roentgen-ray therapy. Results obtained are equally as good if not better than those following the usual methods of treatment. The diseases to be considered are polycythemia, lymphatic and splenomyelogenic leukemia. The rays must be applied in either instance over all the long bones and the spleen.

In polycythemia a reduction in the red corpuscles is readily attained.

Horwitz and Falconer report a case of polycythemia vera. On May 18, 1915, a blood examination showed a hemoglobin percentage of 105, 12,400,000 red blood corpuscles and 9000 white blood corpuscles. The spleen could be palpated about a hand-breadth below the costal border; the edge was rounded, smooth and slightly tender. October 9, 1916, benzene was administered, about 5 gm. per day, until 33 gm. had been taken. November 10 another course of benzene therapy was given until 8.5 gm. had been taken. November 23 to 28, three additional grams of benzene were given. The drug had to be stopped permanently on account of nausea, gastric discomfort and headaches. During the period of September to January seven roentgen-ray exposures over the spleen were made of about 30 ma. minutes each. January, 1917, the blood picture showed a complete return to normal, the red count being 5,200,000, the white count 9200 and hemoglobin percentage 98. The spleen also had completely receded. When last seen, February, 1918, the patient was continuing well.

In lymphatic leukemia the glands must be rayed in addition to the bone-marrow and spleen. A combined treatment of radium and roentgen ray in leukemias is preferable. The radium should be applied to the splenic area and the *x*-rays to the bone-marrow. The white blood count returns to normal and the red blood corpuscles increase rapidly within two or three weeks; the spleen is often reduced to an almost normal size. At the slightest recurrence another course of treatment must be given. Since it appears that the number of the white blood corpuscles increases with a simultaneous enlargement of the spleen we advise splenectomy in every case as soon as the white blood count returns to normal. Splenectomy apparently retards a recurrence. However, when it takes place radiation must be again resorted to, the former splenic area being also irradiated. It is interesting to note that irradiation of the spleen area in splenectomized patients is often followed by a remission. The latter is probably caused by the selective action the leukocyte and myelocyte have to the rays.

INJURIES AND DISEASES OF THE SKULL AND ITS COVERINGS.

By CHARLES E. KAHLKE, M.D.

COVERINGS OF THE SKULL.

ANATOMY.

The several layers of the soft tissues covering the vault of the skull are so constructed and so arranged with relation to each other as to form a most suitable covering for the skull. The first three layers, viz., the skin, the subcutaneous fibro-fatty layer and the occipitofrontalis muscle with its aponeurosis (galea), are so intimately bound together that they form a pad by themselves constituting what is usually spoken of as the scalp. The latter is freely movable over the skull and its closely-fitting adherent pericranium because of the laxity of the subaponeurotic connective tissue. This latter tissue is of such a nature as to admit of the easy accumulation of fluids, even throughout its entire extent, from brow to occiput and from ear to ear, and hence is often incorrectly referred to as a space. In infancy the scalp is very thin and velvety and is very loosely attached. In subsequent years, when possessed of a good growth of hair, it forms a thick, dense, resistant covering. When the hair falls out, or in advanced age, it again becomes thin, but less movable.

The skin of the scalp is exceedingly thick and, under normal conditions, heavily beset with hair follicles and sebaceous glands. The subcutaneous layer of fibro-fatty tissue is very much like the corresponding layer in the palm of the hand, and its connective tissue is so firm as to prevent any appreciable increase in the amount of fat such as occurs in the body in obesity or locally in the form of a fatty tumor. The pericranium is not firmly adherent to the bone except at the suture lines and foramina for vessels. While it serves as a protection to the bone, it has but slight boneforming power in adults, as is very evident after the destruction of the cranial bones from injury or disease.

Blood Supply.—The blood supply of the scalp is very rich and is peculiar in that the vessels are found almost entirely in the skin itself, thus allowing the scalp to be floated upon a large subaponeurotic accumulation of fluid, or even torn away from the skull as a large pedicled flap, without losing its nourishment. The subaponeurotic area contains very few vessels. The chief arteries of supply are the frontal, the supraorbital, temporal, posterior auricular and occipital. In a general way the large veins accompany the large arteries. An important point in the arrangement of the venous system of the scalp is the communication of the superficial veins with those of the diploë and the intracranial sinuses, notably along the sagittal suture, the inner angle of the eye, the mastoid region and along the base generally.

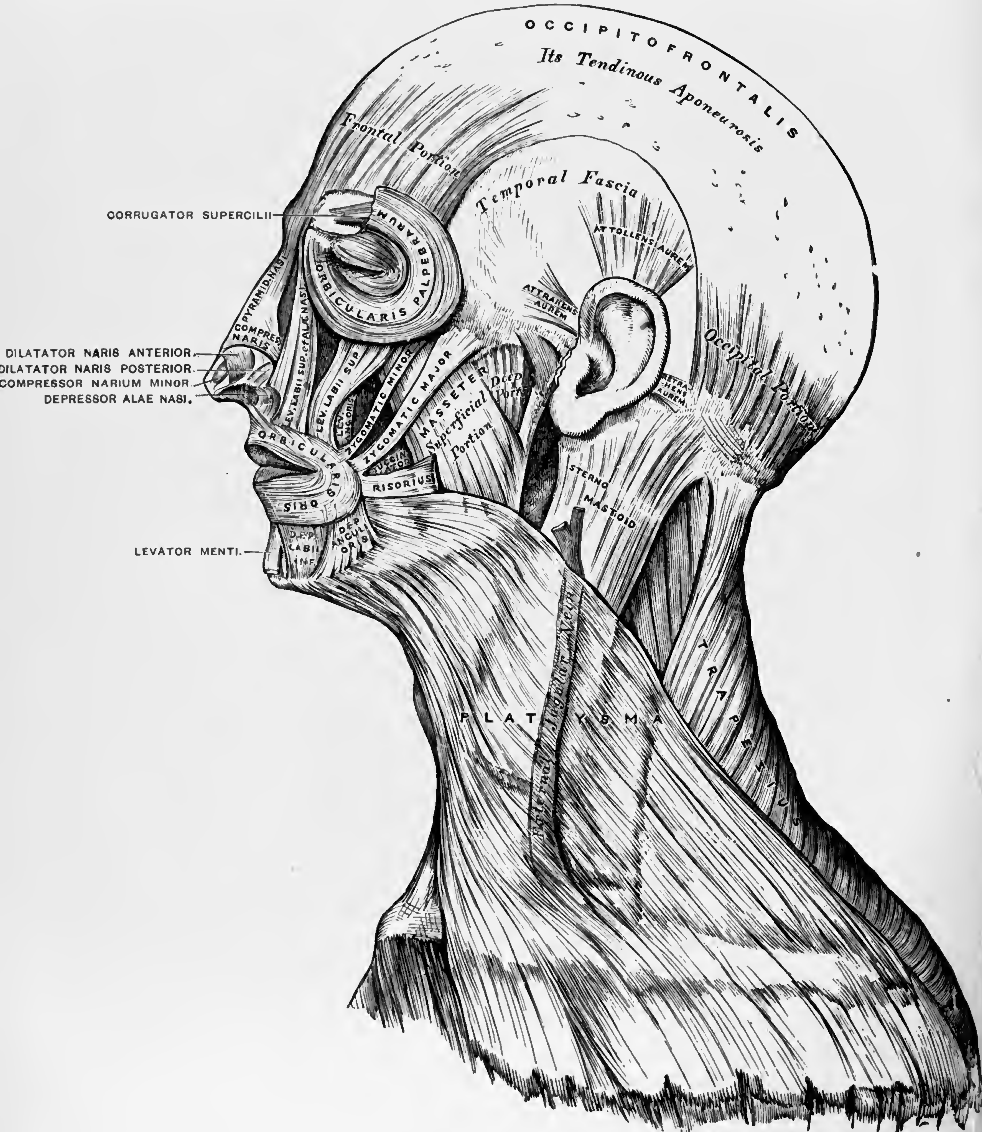


FIG. 47.—Muscles of the head, face and neck. (Gray.)

Lymphatics.—The lymphatic vessels form a very rich plexus over the vault and drain into the necklace of glands around the base of the head; those of the forehead passing partly through the lymphatics of the face into the submaxillary glands, and partly to the parotid glands; those from the temporal and anterior parietal regions to the parotid glands; and those from the posterior parietal and occipital regions to the mastoid and suboccipital glands.

Nerves.—Of the nerves supplying the scalp, those of special interest to the surgeon are sensory, with the exception of one of the temporal subdivisions of the facial nerve supplying the frontalis.

INJURIES OF THE COVERING OF THE SKULL.

Wounds, open or closed, involving the scalp, demand an immediate anatomical diagnosis, as complete as possible. In many contusions we must consider the possibility of an underlying fracture or intracranial injury. If we are dealing with a punctured wound, we must determine whether the subaponeurotic area, the so-called dangerous area of the scalp, has been entered, or whether the skull has been penetrated. Though many of these wounds, from the standpoint of trauma, are insignificant, yet, from their nature and location, they call forth many questions as to hemorrhage or infection in the near future, and as to epilepsy, insanity and various mental states in the remote future. The fate of many a case depends upon the diagnosis and treatment instituted by the physician first called to the case.

Contusions.—In the case of contusion the findings will depend largely upon the force and direction of the blow, and partly upon the size and character of the contusing surface. Thus a direct blow, striking the head squarely, may produce a contusion resulting merely in a hematoma of the subcutaneous or subaponeurotic area, or it may split the scalp in such a way as to resemble an incised wound. If the blow, on the other hand, falls obliquely, it may loosen the aponeurosis from the pericranium or even the pericranium from the bone, resulting in a more extensive extravasation of blood; it may even tear up a flap of the soft parts.

Hematoma.—We recognize as a *subcutaneous hematoma,* a swelling of the scalp which has appeared directly after an injury to these parts, and which has the following characteristics: It is painful, tender, tense and moves with the scalp. Discoloration is more or less marked. Fluctuation is usually not present unless it is over the brow where the skin is more easily separated from the aponeurosis.

Deep hematomata have the same history of trauma and prompt appearance of the tumor, but with these differences: The swelling is usually more gradual in onset and tends to increase in size; is more extensive, and consequently flatter; it does not move with the scalp and usually fluctuates; even pulsation may be noticed where a large vessel has been ruptured, or if there is a coincident skull fracture with gaping. Discoloration is not so marked right after the injury, but may appear later. These deep hemorrhages may lie under the galea or beneath the pericranium. In the latter case they are known as cephalhematomata. If the hemorrhage is under the galea and extensive, its location would be easily recognized; if under the pericranium, it would be limited in outline by the attachment of the pericranium to the suture

Fig. 48.—Large hemotoma under the galea.

lines of the bone; but a hematoma under the aponeurosis, of limited size, and situated over one cranial bone might be difficult to recognize from a collection under the pericranium. *Cephalhematoma* is rare in adults. It occurs chiefly in infants and is due to injury during labor,

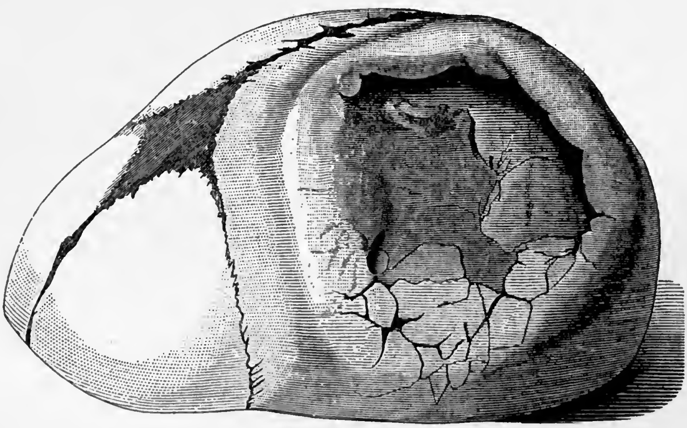


Fig. 49.—Bony wall of subpericranial hematoma.

the hemorrhage coming from the vessels between the pericranium and skull. It appears usually on the second or third day after delivery and tends to increase in size for a time. These deep hemorrhages are alike in that they usually have a firm ring of reactionary edema at the border of the hemorrhagic infiltration of the tissues. This ring is elevated and so hard in contrast to the rather soft fluctuating center of the hematoma, and so gradual in its rise from the surrounding normal tissues, that it feels much like the edge of a depressed skull fracture and is occasionally mistaken for such. Firm and continuous pressure on any point of the ring will cause the ridge to disappear at the point of pressure. In case of reasonable doubt as to fracture it is best to make an incision and examine the skull.

All of the hematomata, both superficial and deep, tend to disappear spontaneously by absorption. Occasionally a large vessel may require ligation. Only rarely will the blood remain long enough under the pericranium to become encysted, thus constituting a *blood cyst.*

Fig. 50.—Suppurating cephalhematoma in an infant of five weeks. Incised. Death in four days. Children's Hospital. (Ashhurst.)

Diagnosis.—The diagnosis in case of a blood cyst is to be based upon the history of injury, the location and non-inflammatory nature of the swelling, the fluctuation, the absence of pulsation and the non-reducibility of the tumor. There may be a thin bony shell rising up from the borders toward the dome, representing the bone-forming power of the pericranium. The exploring needle would reveal reddish or yellowish fluid. It would be differentiated from *meningocele spuria* or *hernia cerebri* by its non-reducibility on pressure, its failure to increase in size or tension with increased intracranial tension, and by the absence of pulsation. *Cephalocele* would have the characteristics of meningocele spuria, but it would be situated in the median line and would be congenital.

Treatment.—In case a hematoma does not disappear spontaneously in the course of ten days or two weeks, it should be aspirated with a large needle or incised. The cavity should be emptied by gentle pressure and a light compression bandage applied. Any thin bony shell should be broken down. Special care should be observed to avoid infection. In case infection should occur it should be recognized early and free drainage established.

Contusion with open wounds should be carefully cleansed by first packing sterile or mildly antiseptic gauze into the wound, shaving the surrounding area and disinfecting in the usual way. Dry shaving, followed by the application of tincture of iodin, is the usual emergency preparation. Benzine may be used instead of iodin, or one part of iodin in 1000 parts of benzine may be used, especially if grease is present in the wound. Benzine is inflammable, and is furthermore very irritating to the skin if allowed to lake or collect in creases or pockets, hence it must be handled with great care. Then the wound should be cleansed with a mild antiseptic, preferably a 1 per cent. or $3\frac{1}{2}$ per cent. iodin solution; all dirt and cinders ground into the tissues should be removed with scissors and forceps. If the edges of the flaps are badly contused or very dirty on the raw edge they should be trimmed off. The skull should be carefully inspected. If no fracture is present the wound should be closed, leaving plenty of room for free drainage. The galea, if cut or torn, as it usually is in a flap wound, should be included in the suture. Where the wound is large it is preferable to shave the entire scalp. This is the best course to follow, too, if the scalp is very dirty. No scalp wound should be explored until every detail of surgical cleanliness has been carried out.

Reasonably clean *incised wounds* are to be cleansed the same as the above, except that it is not necessary, in the smaller wounds, to shave the skin over such a wide area, not at all in some cases. The wound in many cases can be sutured without drainage. If the aponeurosis has been divided, as is evidenced by the gaping of the wound, drainage should be provided. Stitches through the galea should be removed in forty-eight hours (Cushing). It is well to paint the suture lines with $3\frac{1}{2}$ per cent. iodin solution before applying the dressing. In case a moderate-sized flap is entirely cut away an attempt should be made to suture it in place. I recently had an interesting case of a young woman whose head had been forced through the glass wind-shield of an automobile. The glass shaved a thick Thiersch graft, $\frac{3}{4}$ by 4 inches, from her forehead. At one end of the graft was the long hair of the scalp, at the other the hair of the eyebrow. The graft, which I discovered in the matted hair at the back of the head, was cleansed in sterile water and replaced on the wound which had been cleansed with a weak lysol solution. A light dry compression dressing, fixed with adhesive plaster, resulted in a perfect healing, without loss of the hair on the graft. The dressing was not disturbed for ten days.

Punctured Wounds.—Punctured wounds, if deep, should be laid open freely enough for disinfection, hemostasis and drainage. Pockets should be cared for by a counter drain if necessary. If not deep, and if the wound of entrance is small and caused by a reasonably clean object swab the wound with $3\frac{1}{2}$ per cent. iodin solution and dress without suture or drain.

Every case of marked contusion should be carefully watched for intracranial complications and every scalp wound for infection. Deep stitches should be removed in forty-eight hours, superficial ones in five days at the latest.

The prophylactic administration of 1500 units of antitetanic serum may be called for on the same grounds as in other soiled wounds, especially of the punctured variety.

Complications.—The chief complication, barring skull and intracranial injuries, that may arise is infection. If this is circumscribed, whether superficial or deep, removal of a sufficient number of stitches to allow very free drainage from the bottom of the wound, followed by the local application of tincture of iodin, is usually sufficient. Wet boric acid dressings are indicated in the more serious cases.

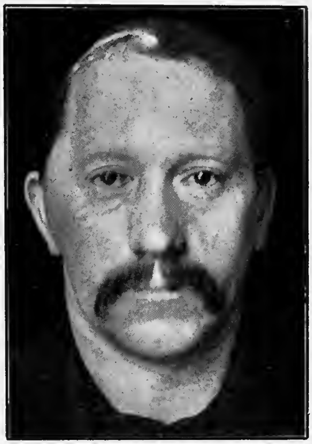


Fig. 51.—Lacerated wound of the scalp, with subaponeurotic cellulitis; the result of sealing the wound with a cotton and collodion dressing. Forty-eight hours after injury the cellular infiltrate had gravitated into the temporal region where it was arrested by the attachment of the temporal fascia to the zygoma. Episcopal Hospital. (Ashhurst.)

If the infection takes the form of a diffuse cellulitis under the aponeurosis we will have the constitutional symptoms of sepsis plus a diffuse swelling and edema of the scalp. In a case of this kind the entire head should be shaved, the stitches removed, the wound opened and counter-drains placed in the lowermost portions of the subaponeurotic area around the head. Wet boric acid dressings are of service here. All infected wounds must heal by granulation, but skin grafting in suitable cases with loss of tissue will hasten the recovery. Extension of the infection to the bones and intracranial regions will be considered under their proper headings.

When any scalp wound becomes even mildly infected the possibilities of the spread of the infection to the skull or intracranial structures is so great that it is not wise to offer a favorable prognosis. To emphasize this point I will cite the following case: A laborer in a factory was hit on the head with a belt which had slipped off its wheel. There resulted a small wound over the left parietal region which did not open the subaponeurotic space, nor were there apparently any evidences of other deeper injuries. A fellow-laborer washed and dressed the wound and the patient continued with his work. When he consulted his physician a week later because of headache, there was found a healthy looking granulating wound, though the patient stated that there had been "some matter" in the wound a few days previously. He grew slowly but progressively worse, with all the classical signs of increasing intracranial tension, plus right-sided convulsions. Operation disclosed an intact skull and dura, but a superficial brain abscess.

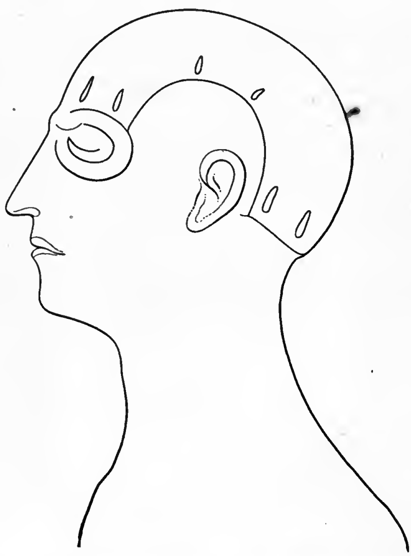


Fig. 52.—Lines for incisions for subaponeurotic suppuration.

Subpericranial suppuration, like cephalhematoma, is limited, at least for some time, by the boundaries of a single bone. This infection may arise secondarily to an osteomyelitis caused by an air sinus infection, or it may develop in a hematoma as the result of operative interference or through hematogenous infection. The diagnosis is to be based upon the history of sinus disease, such as mastoiditis, with the subsequent appearance of a deep fluctuating swelling located over the bone involved. Other cases may give the history of cephalhematoma, with or without operative interference. All of the cases are progressive and are accompanied by the constitutional symptoms of sepsis. The treatment consists of free drainage, and careful watching for complications.

Avulsion of the Scalp.—The entire scalp may be torn completely from the head, or it may retain attachment by more or less of a pedicle. In the latter case the scalp should be sutured in its proper position, with provision for free drainage. Davis,[1] reviewing the literature up to 1911, reports 92 cases of complete and 30 of incomplete scalping. Of the former the scalp was replaced 21 times, but that of Malherbe[2] is the only one which has resulted in even partial success and even this is doubtful, as Lejars in *Urgent Surgery*, vol. 1, 1910, p. 87, speaking of the case says: "The scalp died, but turned into a parchment-like covering which remained adherent to the cranium, and under which healing took place without complications. In such a case the reapplication is practically only a dressing with the skin." Both clinical and experimental evidence shows that it is useless to replace the scalp *in toto* and expect it to heal, but strips of the scalp may be successfully applied to the periosteum along the wound edges, as immediate, whole-thickness grafts.

Perimoff[3] cites a successful case of free transplant of a flap of hairy scalp from the head of a Tartar to the head of a Russian officer, who had a disfiguring scar on the temporal region. The transplant not only lived, but the hair did not fall out afterward. He attributed Lauenstein's failure in a similar case to the use of iodobenzine. Perimoff used only soap and water as cleansing agents.

In complete avulsion early skin grafting by the Thiersch method should be performed. Cushing believes that extensive wounds healing by granulation may lead to delicate scars and possibly epithelioma.

Charles H. Mayo[4] describes a practical method of "hastening the healing of denuded surfaces of bone." He drills holes about one fourth inch apart through the outer table of the skull into the vascular diploë. "Through these perforations granulations are rapidly thrown out and soon merge together on the surface, allowing an abundant blood supply for the skin grafts."

Grafts of skin from the patient give better results than those taken from other individuals. In the latter case they tend to disappear, even though they may "take" in the early stages.

Gunshot Wounds.—As gunshot wounds of the scalp are usually only minor features of serious head injuries the treatment is usually given under the head of skull injuries. In case a spent ball becomes lodged under the scalp without injury to the bone it is good surgery to remove it, as this can be safely done, and thus avoid any irritation and secondary infection. Small shot, from a shotgun, need not be removed if they have entered as a scattering shot from a distance. These shot wounds are to be regarded as clean wounds. Merely painting the wound of entrance with tincture of iodin is all that is necessary.

Cases have been mentioned in the literature of bullets traversing the subaponeurotic area nearly half way around the head without entering the skull. I once saw a case in which a similar thing happened about the chest. In a shot wound of this sort the absence of the usual brain symptoms would be a striking feature, and in all probability the track

[1] Johns Hopkins Hosp. Rep., 1911, xvi, 257.
[2] Bull. méd., 1898, No. 97, p. 1121.
[3] Zentralbl. f. Chir., 1913, p. 1443.
[4] Ann. Surg., September, 1914, p. 371.

of the bullet would manifest itself a day or two later by a streak of discoloration and tenderness. A skiagraph would show no bullet hole in the skull.

That an absence of brain symptoms does not always exclude penetration of the skull is evidenced by a case of mine in which a 22 caliber bullet entered through the eyebrow. A drop of blood at the latter site was wiped away and the incident forgotten, as neither the patient (a boy of twelve) nor his friends knew he was shot. He remained in a normal condition until three weeks later when symptoms of a severe meningo-encephalitis suddenly developed, resulting in death two days later. At the autopsy the bullet was found in the right lateral ventricle.

Powder stains on those portions of the scalp not covered by hair are usually so disfiguring as to demand treatment. In recent cases the little grains of powder may be picked out with a needle or sharp-pointed knife, or they may be treated by the hydrogen-dioxide method. Crile,[1] Rhoads[2] and Clark[3] report satisfactory and rapid results. The site of the stain should be kept moist, preferably by wet dressings of the hydrogen dioxide, unless the latter is too irritating. Crile states that after a white zone has appeared around and under the grains the latter can be easily picked out with a pointed instrument. Clark applied a wet dressing of one part of glycerin and three parts of hydrogen peroxide, if not too irritating, and the stains disappeared.

Stelwagon[4] speaks very highly of the method of removal of the grains by a cutaneous trephine of small caliber, as originally suggested by Watson.[5] The small punch is pressed firmly, but not too deeply over the speck, using a rotary motion. The little disk of skin which protrudes through the opening is snipped off, and the cavity filled with powdered subsulphate of iron or with a paste of the tincture of benzoin and boric acid, or with the compound powder of boric acid or acetanilid. He also mentions the method of tattooing in glycerol of appoid or caroid. Brault tattoos the stained area with a needle and solution of 30 parts of zinc chloride to 40 parts of water, then paints this area lightly with the same solution after tattooing. This method may produce a deep eschar if not skilfully carried out.

Many authors advise the use of the electrolytic needle. If the grains are thickly set the superficial layer of the skin may be shaved off and skin grafts applied.

DISEASES OF THE SOFT COVERINGS OF THE SKULL.

Erysipelas.—Erysipelas, though it occurs oftenest about the head, is not common as a primary scalp infection. When it involves the scalp by migration from the face the diagnosis is easy, but when it starts in the hairy scalp the condition may be unrecognized until it reaches

[1] Cleveland Med. Gaz., 1896–1897, xii, 183. [2] Am. Med., 1901, i, 16.
[3] Ibid., 1901, p. 384.
[4] Treatise on Diseases of the Skin, 7th ed., Philadelphia, 1914.
[5] Med. Rec., 1878, xiv, 78.

the free surface outside of the hair line, where it takes on all the local characteristics of the disease. This is because of the fact that in erysipelas of the hairy scalp there is no marked redness or elevation of the skin and hence no sharp cut line of demarcation. There is, however, some edema and tenderness on pressure over the involved area, and enlargement and tenderness of the nearest lymphatic glands. Always however, there are the usual constitutional symptoms which accompany erysipelas, viz.; a sudden rise of temperature, often to 103° to 104°, initiated in most cases by a chill. Headache, vomiting and a rapid pulse are common. The scalp cases often have a stormy course from the beginning, with delirium and even unconsciousness as prominent symptoms. The disease is usually of the nine-day type. These cases sometimes arise after the drainage of deep abscesses, as in cases of mastoiditis. For this reason some have advised that the opening of these abscesses be made with a cautery for the sake of sealing up the lymphatics. This latter treatment, however, does not seem indicated, and is seldom used.

Prognosis.—The prognosis is not bad if the patient is a healthy adult. Complications, such as phlegmon or intracranial infection, are rare except in infants or debilitated people, or where there has been deep contusion with hematomata or fracture—or in cases of meddlesome treatment. The prognosis is bad in alcoholics.

Treatment.—Nutritious liquid diet, good elimination of the toxins through the use of laxatives and the free administration of water by mouth or proctoclysis, combined with the local use of mildly antiseptic cooling lotions, such as equal parts of alcohol and saturated boric acid solutions, are all that have as yet proved of value in the line of treatment. While the mild lotions may relieve pain they sometimes cause eczema and so may occasionally do harm. Antiseptic ointments may be necessary to relieve intense itching. The solution of equal parts of alcohol and saturated aqueous solution of boric acid is used as a wet dressing, being covered with gutta-percha tissue. If the face also is involved the dressings are cut in the form of a mask. Sera have thus far not proved efficient. Scarification and circumscribing incisions are to be reckoned as meddlesome. Clipping of the hair will permit more efficient cleansing of the scalp. An ice-cap may control the delirium. Abscesses are to be drained, and a failing heart is to be stimulated.

Carbuncle.—*Local suppurations,* such as pustules, boils or carbuncles of the hairy scalp are uncommon, except at the hair line in the occipital region. The carbuncle usually starts on the back of the neck and invades the hairy scalp secondarily, though I had one case starting in the hairy scalp just above the base of the mastoid process. The carbuncle begins like a boil on the surface of the skin, but soon spreads into the deeper tissues, usually to the fascia covering the muscles, giving rise to a firm, brawny induration rising up somewhat like a truncated cone. It is painful and tender, and the skin soon undergoes the characteristic color changes of inflammation from a red to a reddish purple. In this dense mass of subcutaneous necrosis are multiple small pockets of pus which break through the discolored surface at numerous points, giving rise to the so-called pepper-box openings. In spite of these spontaneous openings the process tends to spread progressively and in some cases may become as large as a small dinner plate. The temperature may not be marked.

Prognosis.—While the prognosis is good in healthy young adults, it is bad in the aged, the debilitated, and in those suffering from diabetes, in whom it is so common. In any case the prognosis is distinctly more favorable if the condition is recognized early and the focus promptly excised. Simple incisions are not very satisfactory, and curettement is dangerous, because it may disseminate the infection.

Operation.—The operation which is probably as satisfactory as any other is one in which two skin flaps are raised, through an H-shaped incision. After the excision of the necrotic mass and painting the deep wound with tincture of iodin the flaps are sutured, but free drainage instituted. The operation should be done under gas and oxygen anesthesia.

Syphilis of the Scalp.—Syphilis of the scalp is of interest to the surgeon in its tertiary stage only. It offers little difficulty as a rule in diagnosis, especially when accompanied, as it usually is, by other manifestations of the disease. Even if a gumma exists as a solitary lesion it possesses characteristics which stamp it as luetic. On the scalp the favorite seat is the forehead, occasionally the parietal region. It may start as small, flat, reddish-brown nodules in the skin or as a subcutaneous node. In the former case they are multiple, are usually arranged in groups and tend to ulcerate in the center while they proliferate at the periphery of the group. The ulceration is in turn usually followed by healing. The solitary subcutaneous nodule develops as a slow inflammatory process which may become arrested and absorbed, or which may break down and ulcerate. The skin, which is at first movable over the nodule, later becomes fixed, discolored, and breaks down. Their favorite seat is on the brow, back of the neck, back or shin.

The characteristics of the syphilitic ulceration are the sharply punched-out appearance of the edges, the dirty sloughing grayish base, and the tendency to heal with the formation of radiating scars. Where there are multiple coalescing skin lesions the general shape of the ulcer is spoken of as serpiginous. In the latter case the most of the forehead and parietal regions may be covered with these irregular ulcers and scars. When the solitary ulcer heals it usually leaves a round depressed scar.

Diagnosis.—The diagnosis in most cases can be made upon the appearance of the local lesion. However, concomitant lesions in other parts of the body and the presence of a positive Wassermann reaction, or the finding of the spirochetes, clinches the diagnosis. The history of the primary and secondary manifestations, when it can be obtained, also has much weight. The spirochetes are only occasionally found in tertiary lesions. They seem to be very few in number and are found only

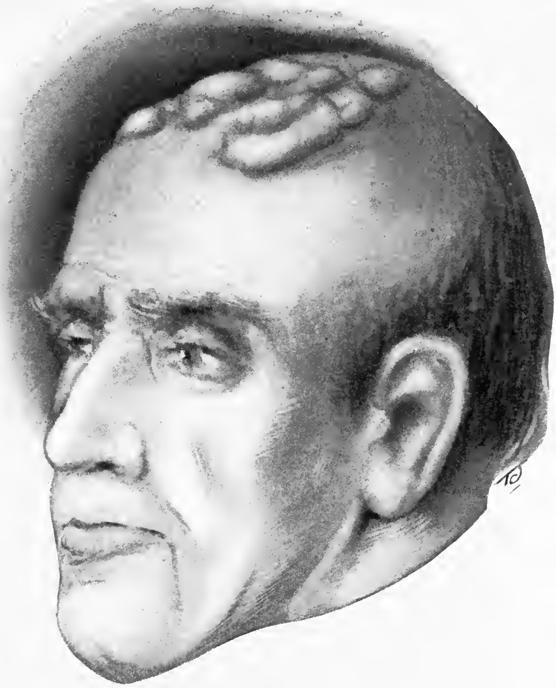


Fig. 53.—Syphilis of the scalp. (Hertzler.)

Fig. 54.—Syphilis. Nodular gummatous type. (Knowles.)

after diligent search. That they are sometimes present in even late tertiaries is evidenced by the occasional, but unquestioned, infectivity of these lesions in man and, experimentally, in monkeys.

In the *differential diagnosis* we must exclude *lupus, sarcoma* and *carcinoma*. *Lupus* occurs most frequently upon the face, near the nose, rarely upon the forehead. It is of slower growth, has not the serpiginous outlines, and has the pale flabby granulations so characteristic of tuberculosis. The edges of the ulcer are irregular, flat and undermined. In the vast majority of cases the nearest lymph glands are involved, as are also other tissues and organs in the body. Most cases will give a positive tuberculin reaction. *Sarcoma,* like gumma, may

Fig. 55.—Destruction from syphilitic gumma. (Knowles.)

spring as a solitary nodule from the pericranium or subcutaneous tissue. Like gumma it may be bluish-red and softened in the center as it reaches the skin, but it does not present the bogginess so often seen in gumma, as for some time it is more or less encapsulated, due to its growing by expansion into the surrounding tissues rather than as an inflammatory infiltration. When a sarcoma leads to necrosis of the skin the resulting ulcer presents more of a hemorrhagic or yellow gelatinous degeneration, whereas a gumma, on opening, reveals a sticky, gummy, cheese-like mass in the center. Sarcoma is of more rapid growth than gumma. Furthermore, those not of bony origin usually arise in the skin rather than in the subcutaneous structures and belong to the class known as *melano-sarcoma*. This is the most frequent variety found in the skin, and it starts as a rule from a pigmented mole or nevus. It is exceedingly malignant and grows rapidly. *Carcinoma* may appear as a deep growth but is then secondary. The *superficial epithelioma* is ordinarily easily recognized by its irregular, indurated, elevated margins and a base which bleeds on the slightest irritation. It almost always has its starting point in a wart, an old scar, or in the edge of an old unhealed lupus. The glands are involved late. It is seen mostly on the brow or temporal region below the hair line.

Non-neoplastic Swellings.—Swellings containing air may occur as solitary air chambers beneath the pericranium or as an emphysema. The former condition is known as *pneumatocele capitis* and arises from an open communication between the subpericranial area and the outside air through some air-containing cavity like a sinus (frontal or mastoid). It may be bilateral in the frontal and occipital regions. The communication may be congenital, or it may be acquired through injury (fracture), or disease resulting in erosion of the bone.

Fig. 56.—Pneumatocele of cranium.

Diagnosis.—The diagnosis is to be based upon the presence of a swelling overlying the bone containing the sinus involved, the swelling presenting the following characteristics: It is non-inflammatory and painless; is tympanitic on percussion; reducible on pressure and refills promptly on forced expiratory efforts, sneezing, coughing, etc. In addition there is usually the history of injury or disease involving the sinus. The bone itself may feel rough at the periphery of the swelling, owing to the mild bone-forming powers of the pericranium.

Emphysema presents itself as a more or less diffuse flat swelling which occurs right after a fracture involving one of the air-containing sinuses. It may involve the subaponeurotic or subcutaneous area and sometimes increases in area on forced expiratory efforts. Pressure on the swelling elicits a characteristic dry crackling under the skin.

In the *differential diagnosis* of *pneumatocele* it may be said that the location and time of appearance would exclude *meningocele*, the latter being congenital and mesially located. As the air sinuses do not develop until puberty, pneumatocele would be rare before that time. Because of the not infrequent occurrence of *tuberculosis of the mastoid* it may be necessary to exclude *cold abscess* underneath the pericranium. In this case the swelling, while fluctuating, would not be reducible on pressure and would be dull on percussion. The abscess tends to work its way to the surface. The history of the disease and the presence of enlargement of the nearest lymph glands would also point to cold abscess. *Cephalhematoma* (blood under the pericranium) is most frequently found over the parietal bone the second day after birth, but may occur at any age, after injury, and in the same location where pneumatoceles occur. The swelling, however, is not reducible, and is dull on percussion. Ecchymosis will probably be present after the lapse of a few days. As in air tumor, there is apt to be a ridge of bone at the periphery if it lasts more than two weeks. The exploring needle would settle the diagnosis.

A *pericranial sinus,* though infrequent, should be thought of. It consists of a "blood cyst" of traumatic origin, situated between the pericranium and the bone. The reported cases have been found over the brow or on top of the head near the median line, and none has been larger than a walnut. As they contain circulating blood and communicate with the superior longitudinal sinus it is evident that they are reducible on pressure, and develop tension on forced expiratory efforts or when in a dependent position. They are dull on percussion. A small exploring needle would settle the diagnosis.

Treatment.—The treatment of pneumatocele that offers the most certain results is the König-Müller osteoplastic operation, though in a number of cases other methods, such as incision and packing, with compression, freshening the edges of the fracture, etc., have been successful. Puncture with the needle, or simple compression, iodin injection, etc., are not favorably considered. One would naturally suppose that in the case of the mastoid a puncture of the ear drum, or a drainage operation in case of the frontal sinus, would effect a cure by preventing air tension. Infection calls for drainage.

Emphysema arising from an air-containing sinus calls for no treatment.

The treatment of the *pericranial sinuses,* like that of spurious meningoceles, is to let them alone, unless the underlying cause can be relieved. Harvey Cushing described two cases in connection with brain tumors which disappeared after decompression.

Meningocele Spuria (Traumatica) or Cephalohydrocele Traumatica.—This, as its name implies, is a false meningocele of traumatic origin. It is found only in children and, while its existence implies both subcutaneous fracture and rupture of the dura, its persistence implies some alteration in the secretion or absorption of the cerebrospinal fluid which leads to a persistent increased intracranial tension. For this latter reason the skull opening does not close and we have what is known as the chronic form. The acute varieties without persistent increased tension may close spontaneously, or after aspiration and compression dressing.

Diagnosis.—The diagnosis is to be based upon the history of injury during birth, or later as the result of a fall or other accident, followed immediately by the appearance of a circumscribed fluctuating tumor beneath the scalp. This tumor pulsates synchronously with respiration and the heart beats, and possesses a tension which varies with the intracranial tension, *i. e.*, it is increased when the patient cries, coughs or sneezes, or when the head is in a dependent position, and diminishes when the child is quiet or when the head is elevated. Reduction by pressure may lead to symptoms of acute brain compression. As the condition follows fracture the tumor is not usually situated in the median line, as is true of meningocele. The use of the exploring needle may be necessary to settle the early diagnosis.

Fig. 57.—Meningocele spuria traumatica

Fig. 57 is a photograph of a two and one-half year old boy who, eighteen months previously, fell out of an upstairs barn door, striking on the back of his head. There was no evidence of serious trouble until several days later when the meningocele was noticed. Two months after the accident I found a fluctuating swelling the size of a grapefruit. It had all the characteristics of a meningocele. On deep pressure the corners of the bones at the lambda could be felt curled outward. The child was otherwise normal and had no signs of choked disks.

One month later the boy fell from his little wagon, striking on the tumor. Violent convulsions followed for several hours. These gradually subsided, leaving a left-sided paralysis which has gradually disappeared until at the present time he is about normal, except for the presence of the tumor.

No operation was performed.

Treatment.—Though various operations have been devised, surgical treatment is useless, for it is a fact that under normal conditions the fracture will heal spontaneously, while with persistent increased tension an opening will be maintained in spite of operation. Furthermore the cerebrospinal fluid is apt to find its way through the scalp wound. To say the least, operation will not only fail in most cases, but a distinct danger of leakage and infection will have been added.

TUMORS OF THE SCALP.

Dermoid Cysts.—Dermoid cysts, being congenital, are first noticeable at birth or any time up to puberty, and are found at special points of predilection where there has been an infolding of the skin, viz., at the outer border of the orbit, or deep in the orbit, in the region of the mastoid and squamous portions of the temporal bone, and in the median line of the skull, especially at the root of the nose and the region of the fontanelles. They are deeply situated above or beneath the pericranium, often resting in a saucer-shaped depression in the bone, or even hanging from the bone with a connective-tissue pedicle, especially in the occipital region. They may even rest on the dura and thus pulsate with the brain. In very rare cases they may be found in the bone itself, especially in the mastoid. Not being attached to the skin, inflammation is rare.

Differential Diagnosis.—The differential diagnosis is usually not difficult, especially if the dermoid is found in one of its favorite locations In the rare cases where it is resting on the dura in the median line it may be mistaken for *cephalocele,* which occurs usually at the glabella, or near a fontanelle. In the latter condition the variations of intracranial tension produce corresponding variations in the tension of the tumor. Furthermore, cephalocele is more or less reducible. The very rare cases of *serous cysts* found deep in the midline are probably *brain cysts* isolated from the intracranial space during closure of the sutures. *Sebaceous cyst* is attached to the skin, is entirely above the galea, occurs later in life, and is seldom found in any of the favorite seats of dermoid cysts.

Treatment.—The treatment consists in early excision, care being taken to avoid injury of the dura in the cases resting on the latter.

Sebaceous Cysts.—Sebaceous cysts commonly known as *atheromatous cysts,* or *wens,* offer no difficulties in diagnosis. They are oval tumors situated partly in the skin and partly in the subcutaneous tissues, varying in size from a pea to a walnut. Occasionally they may be much larger. The small ones are hard, the larger ones soft. As the tumor grows the overlying skin becomes tense, thinned and devoid of hair. The skin at the summit is adherent and dotted with comedones. They occur mostly in adult life and are rare before puberty. They are often multiple in advanced life. They grow slowly and are painless unless inflamed. In very rare cases they have produced sufficient pressure to cause atrophy of the underlying bone. They may be pedunculated in the occipital region.

Treatment.—The treatment is excision under local anesthesia, the essential feature being the complete removal of the sac. The latter may be difficult in case a friable, thin-walled cyst should rupture during the operation, especially as the surrounding tissues are very vascular and bleed freely. An elliptical incision which allows the adherent skin to be removed with the sac facilitates removal without rupture of the sac.

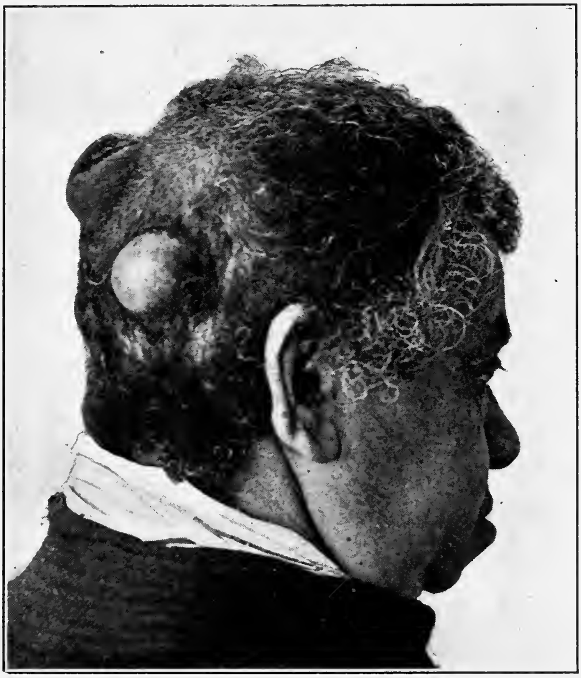


Fig. 58.—Wens. Many years' duration; movable, non-sensitive, hard. (Martin.)

Adenoma.—Adenoma of the skin is a very rare tumor. It may arise from a sebaceous or sweat gland and may appear in the form of a warty growth or a subcutaneous tumor. In the case of the adenoma sebaceum one can often see the openings of the sebaceous glands. Some of the glands may develop into sebaceous cysts.

Cutaneous Warts and Horns.—Cutaneous warts and horns which occur in the hairy scalp are readily recognized. As they are not infrequently the starting-point of malignant growths the *treatment* should be complete removal, the incision being deep enough to prevent recurrence.

Hard Fibroma.—Hard fibroma is a very rare tumor of the scalp. The case reported by Cushing from Halsted's clinic was a slow-growing hard tumor attached to the movable scalp. It had a mushroom shape and was covered with a thin epithelium devoid of hair. The *soft fibromata* found on the scalp are part of a generalized fibromatosis (Fibroma molluscum) and are easily recognized. The *treatment* is excision, chiefly for cosmetic reasons.

Keloids.—Keloids are quite common in the scalp and offer no difficulty in diagnosis. They are found chiefly in the negro race. Their starting-point is in the superficial scar of a wound or healed infection, and as they involve only the reticular layers of the cutis, they are movable with the skin. Their general appearance is that of a red, shining, hypertrophied scar, covered with epidermis, but free from hair. At times they take on the form of nodular new growths of considerable size.

Differential Diagnosis.— *Hypertrophied scars* rarely attain much size, and after a time tend to disappear spontaneously. They are seen chiefly in those with a personal or family history of tuberculosis.

Treatment.—As keloids usually recur after removal, operation is not indicated, especially while the growth is enlarging. As to remedies warranting some consideration the following may be mentioned: Thyroid extract, usually in conjunction with x-ray; thiosinamin or fibrolysin injected into the keloid. Static electricity in the form of sparks is also well spoken of by some observers. The x-ray is probably the best form of treatment. Ochsner states that he has had many keloids disappear and remain permanently well after intensive x-ray treatment. He gives a vigorous treatment daily for six days; then repeats this procedure in one month.

Frank E. Simpson[1] describes the efficiency of radium rays in the treatment of keloids. Some experience is necessary in order that one may estimate the amount of raying necessary. The apparatus and technic employed vary somewhat with the type of lesion. "In practice the theoretic use of purely selective doses, which may cause the keloid to disappear, must often give way to the more rapid method of destructive doses. The general principle of using a sufficient dose to produce a slight but not an excessive reaction is the one I usually follow." He states that "In upward of a dozen keloids of various types which I have treated with radium, the results have been superior to those obtained by other methods."

Lipoma.—Lipoma is rare in the scalp When present it is most frequently found on the forehead, under the occipitofrontalis muscle or under the fascia of the temporal muscle. Being situated deeply it loses the characteristic lobulation of the subcutaneous variety, and there is of course no dimpling of the skin. It is immobile because it is usually attached to the pericranium. It is slow-growing and sessile, though the pedunculated variety has been seen.

Differential Diagnosis.—The favorite locations for *dermoids* are seldom the seat of lipoma. Dermoid is noticeable at birth or up to puberty,

[1] Jour. Am. Med. Assn., April 17, 1915, pp. 1300 and 1301.

lipoma usually later. *Cold abscess* gives a history of preceding tuberculosis of a bony sinus (frontal or mastoid), and tends to perforate the skin. The course is not so chronic. While *cephalocele* is congenital and occurs in the median line, and presents all the characteristics mentioned under the diagnosis of this condition, still it must not be forgotten that lipoma sometimes overlies it.

Diseases of the Nerves of the Scalp.—*Neurofibroma, Elephantiasis Nervorum, Plexiform Neuroma, von Recklinghausen's Disease.*—This is a rare disease of early life, involving the scalp nerves, and characterized by a fibrous thickening of the peri- and endoneural connective tissue. It is situated entirely within the movable scalp and starts by predilection in the frontotemporal region, often from a wart or mole, and frequently after injury, and spreads out over the side of the head. In a well-developed case the side of the patient's head looks like a landslide, dragging the ear and outer angle of the eye with it. The scalp may sag even to the shoulder as a pendulous mass. The skin presents the usual appearances of elephantiasis, thick, rough, ridgy and sometimes fissured or ulcerated. There is no pain unless the case is complicated by secondary changes.

Diagnosis.—The only condition to be considered at all in *differential diagnosis* is multiple *fibrosarcomatosis* of the peripheral nervous system.

Treatment.—Operation is performed for cosmetic reasons and because of the possibility of the development of sarcoma. The dangers of the operation are hemorrhage and infection, for evident reasons. Because it is a superficial affection it is not necessary to go below the subcutaneous tissue.

The *hyperesthesias, neuralgias* and *herpes zoster* are considered in another chapter.

Bloodvessels. — **Conditions Due to Injury.** — *Blood cyst* or *sinus pericranii* has already been described as often being due to a torn emissary vein near the median line of the skull. It contains circulating blood and communicates with the superior longitudinal sinus.

Traumatic Aneurysm.—Traumatic aneurysm, usually of the temporal artery because of its exposed situation, is easily recognized by the classical signs of such condition. Here we have a tumor appearing suddenly at the site of an injury, the tumor possessing an expansile pulsation, a thrill and a bruit synchronous with the heart beat. Pressure over the vessel on the proximal side of the tumor stops these symptoms and leads to a diminution in the size and tension of the tumor. Pressure on the distal side leads to increase in the size and tension of the tumor.

Treatment.—The treatment is proximal and distal ligation and extirpation.

Arteriovenous Aneurysm.—Arteriovenous aneurysm has the same history as traumatic aneurysm. The pulsating tumor possesses a thrill and bruit, exaggerated during systole. In addition, the anstomosing venous trunk and its immediate tributaries are markedly dilated, and pulsate with the artery, owing to a reversal of their stream.

Aneurysmal Varix.—Aneurysmal varix is the same as the above except that there is no sac or tumor. It is sometimes quite difficult to differentiate clinically the arteries from the veins, and occasionally it may be difficult to differentiate this condition from a racemose aneurysm.

Fig. 59 is a photograph of a case of aneurysmal varix due to a shot wound sustained fifteen years previously. The patient, in getting out of a boat, drew the gun, muzzle first, out after him, with the result that the gun was discharged, many duck shot being deeply embedded in the side of his face. The buzzing tumor was noticed immediately afterward. Though the venous enlargement was progressing very slowly an operation was demanded to relieve the buzzing. During the operation for ligation of the external carotid between the superior

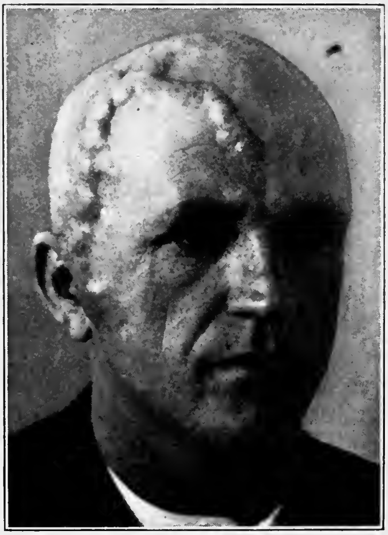


Fig. 59.—Aneurysmal varix.

thyroid and lingual arteries the veins in the neighborhood were found to be very much dilated. The facial was the size of my little finger, while the temporal was half again as large. The ligation stopped the buzzing completely. Excision was impossible as the anastomosis evidently occurred in the external carotid near its bifurcation in the parotid gland.

Treatment.—The treatment for these cases is extirpation or exclusion, if possible, of both arterial and venous trunks near the sac or anastomosis. This may be difficult owing to the distended thickened veins in the dense tissues of the scalp. Cushing advises the plan which Krause and Körte practice in cases of cirsoid aneurysm, viz., lifting a skin flap through a crescentic incision, and dissecting the vessels from underneath. The incision is to extend down to the galea.

Cirsoid Aneurysm, Aneurysm by Anastomosis, Plexiform Angioma, Rankenangiom, Angioma Arteriale Racemosum.—Of all the terms applied to this rare condition, the last one is the most descriptive, for it is really more of an arterial angioma than an aneurysm. It consists of a tumor-like aggregation of dilated, elongated and tortuous arteries, involving primarily some definite "arterial tree." This dilatation implicates even the fine capillaries and sometimes also the veins. It seems to progressively invade the apparently normal vessels at the periphery until at times even the entire scalp and face may be involved. The cause of this condition is not known, but the starting point is often a simple angioma or vascular scar. Trauma is sometimes a factor. It usually starts in the region of the temple or ear, though it may be found in any portion of the scalp or in other parts of the body.

Fig. 60.—Cirsoid aneurysm of the scalp. (Hertzler.)

The tumor is rather flat and presents an irregularly undulating surface, only slightly raised above the surrounding surface. Through the thin overlying skin can usually be seen a bluish tint and the pulsating vessels. On picking up the skin and vessels between the fingers the plexus of pulsating arteries and veins feels like a bunch of earth worms. A distinct systolic thrill and bruit are present and they cannot be obliterated by pressure. Subjective symptoms of noises in the head, dizziness and faintness are common. There is always danger of fatal hemorrhage.

Differential Diagnosis.—Differential diagnosis may possibly call for consideration of arteriovenous aneurysm or aneurysmal varix.

Treatment.—The treatment consists in extirpation if possible. This should be attempted, if the risk is not too great, because of the danger of hemorrhage in the non-operated cases. When one stops to consider that sometimes the vessel changes extend through deep communicating vessels to the subaponeurotic area or even to the intracranial region, the possible difficulties are manifest. The most successful of the radical procedures is that consisting of the raising of a flap of scalp and vessels with dissection of the vessels from the undersurface of the flap. This is facilitated by first ligating the external carotid or, in suitable cases, by the application of a rubber constrictor about the head just above the ears. The next best treatment so far has been the multiple ligations at the borders at different sittings. Simple ligations of the main afferent trunks are of no service, while injections, cauterization, etc., carry with them real dangers rather than benefits.

Wyeth reports a case involving one-half of the scalp cured by the injection of boiling water. Under ether he injected the water along the course of the chief arteries leading to the tumor, then through the tumor from side to side in various directions until pulsation ceased. The case remained well. The following is quoted from Wyeth's article: "The needle was entered along the course of the arteries leading into the tumor, beginning about two inches from the mass, a quantity of boiling water sufficient to coagulate these vessels being employed. It was then introduced through the tumor from side to side, injecting about a dram, withdrawing the needle for one-half of an inch and then repeating this procedure until the entire mass had ceased to pulsate. The quantity of boiling water so used was between five and six ounces. Temperature on the surface was noticed by touch, and when the heat became very perceptible to the hand and the skin began to bleach, the injections in that particular area were discontinued. The warty growths noticed on the surface of the scalp were touched with the Paquelin cautery. No reaction followed the operation. The patient complained of no pain, but there was a very considerable edema of the scalp, and this, beginning on the left (the side of operation), closed the left eye and spread over the face, closing the right eye within forty-eight hours. The swelling spread as far down as the neck and was so great that had I cause to repeat a similar operation I would use only about one-half the quantity of water, and would then repeat the operation after an interval of about a week."

Neoplastic Vessel Tumors. Vascular Nevi.—These are either congenital or develop soon after birth, and are found in the vast majority of cases about the head. It is the prognosis and treatment, rather than the diagnosis, that is of the greatest interest to the surgeon, for the diagnosis is easy except in those deep cases occurring primarily in the bone or its covering.

Angiomas.—Some of the simple *angiomas*, or *port-wine stains*, disappear spontaneously. This is noticeable chiefly in the flat variety,

PLATE I

Multiple Nevi, Affecting Scalp, Forehead, Left Foot, etc., in a Baby Aged two and one-half Months. Episcopal Hospital. (Ashhurst.)

those producing no elevation or deformity of the skin surface, and particularly those of this type which occur on the brow. On the other hand those producing more or less elevation and irregularity of the skin surface, especially if they have a distinct arterial or gross venous character, tend to either remain as they are, or more often to grow progressively worse.

A simple port-wine stain may develop into a cavernous angioma or into a racemose angioma.

The *cavernous angioma* differs from the simple variety in that it consists of larger veins, and is situated chiefly in the subcutaneous rather than in the cutaneous area. It always appears more like a tumor and does not tend to disappear spontaneously, but rather tends to increase in size, at times invading adjoining muscles, bones, etc. These angiomata are to be recognized by the bluish appearance of the veins, visible through the irregularly elevated skin surface, their peculiar spongy compressibility, and the variations in size and tension corresponding with the variations in intravenous pressure. Because of their peculiar bluish tint they have occasionally been mistaken for *thin-walled cysts.* With care this error should not occur. A *cavernous* or *telangiectatic lipoma* may offer serious difficulty in *diagnosis,* but this is an exceedingly rare condition. Under these circumstances it would be impossible to reduce by pressure the size of the tumor to the same extent as in the uncomplicated angioma. *Blood cysts* due to complete isolation of certain sections or spaces from the rest of the angioma are very rarely found in cases of cavernous angioma.

Treatment.—*Early excision* for all kinds of small angiomata is unquestionably the best treatment. The incision should be made outside of rather than through the tumor. It is particularly important to excise the *cavernous* varieties early as they constitute the most formidable and aggressive group, often becoming inoperable. Those cases having a distinctly *cavernous* character and which are too extensive for operation, or which are so situated that operation would give a poor cosmetic result, should be treated by the injection of boiling water into the tumor as recommended and practiced by John A. Wyeth. His method of treatment of the cavernous angioma is the same as described under cirsoid aneurysm, except that he advises peripheral compression "to preclude as far as possible the danger of embolism."

Another method for the *cavernous angioma,* probably not so good, is the multiple puncture with the cautery needle at numerous sittings. Cures have been reported following multiple partial excisions at different sittings.

The following description of Wyeth's treatment of the *superficial capillary angioma* is taken from his article referred to above: "I have employed this method successfully and without accident in a number of cases of capillary angioma, but on account of their superficial character, they being within the substance of the integument, some cicatrization is apt to result unless very great care is taken. The weak tissues of the new growth do not offer the resistance of the normal skin which overlies the venous or arterial angiomata, and may break down under the hot water. In all of my cases the scarring has been very slight, and I think the method is well worthy of thorough trial in these cases. As they occur chiefly in children and are situated on the face, it is important to have the patient very firmly held while the injections are being made without narcosis. The legs, arms, body and head should be kept immovable, while the face should be covered by a mat in which an aperture is cut sufficient to expose the area to be injected. I take the additional precaution to have an assistant hold a sponge saturated with cold water immediately over the needle in order to prevent scalding the cuticle should the apparatus leak. The small hypodermic needle is used, and this should be thrust through the sound skin, about one-eighth of an inch from the edge of the angioma, pushed beneath the neoplasm, care being taken not to let the point come through the surface. From 5 to 15 minims of water may be injected in one spot, changing the needle here and there to suit the size of the mass. When the injections are made directly into the enlarged capillaries, necrosis almost always occurs, but if the water is forced well beneath the surface, the deeper parent vessels will be coagulated, causing the nevus to disappear by gradual denutrition (granular metamorphosis). It is a wise precaution to cover the area injected at once with aseptic collodion to prevent infection. This operation may be repeated from time to time until a cure is effected."

The *simple angiomas* or *port-wine stains* that are too large for operative treatment may be treated with the carbon dioxide snow. W. A. Pusey,[1] states that "The most useful field for the agent (Solid Carbon Dioxid) is in the treatment of nevi, both pigmentary and vascular. Moles, which are small pigmented nevi, you can get rid of early by freezing two or three times from half a minute to a minute. With pigmented nevi up to the size of a coin you can usually get practically perfect results. With large nevi the results are only relatively good, but better than by any other method.

"In the flat nevi, port-wine marks, where there is simply a red discoloration of the skin, you cannot get as good results as in cases where there is an excess of tissue to work on. In these lesions up to the size of a coin in young children I have been able to get excellent results, but in the larger lesions the results are not as good as can be gotten with radium or *x*-rays or with these combined with carbon dioxid. In small elevated nevi, no matter how cavernous, one can usually get almost perfect results, especially when treating young children."

The snow is collected in chamois skin bags or in some mechanical contrivance and formed into sticks or pencils of the desired size. The degree of pressure and the duration of the freezing determine the amount of reaction. The time of freezing varies from five seconds to a

[1] The Therapeutic Application of Solid Carbon Dioxid. Ill. Med. Jour., February, 1912.

minute or more. The tissues in children are naturally more sensitive and require the minimum amount of exposure. With an application of ten seconds' duration in children you get as much reaction as with thirty seconds in adults. Pusey advises caution in treating the terminal areas of circulation, as the borders of the ear, the bridge of the nose, the extremities, particularly the legs.

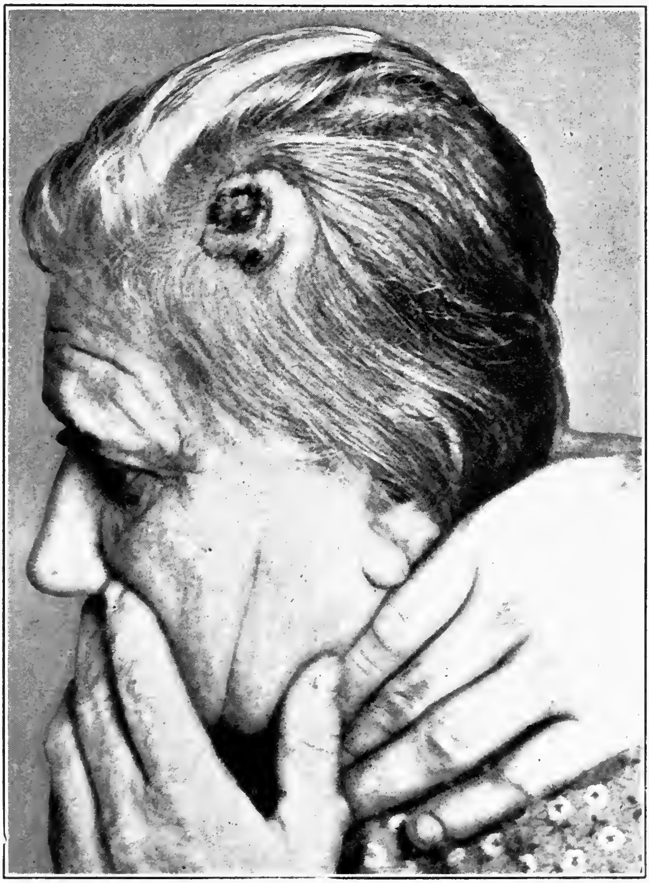


FIG. 61.—Epithelioma of scalp. Chronic sloughing ulcer, irregular in outline, with elevated borders and infiltrated reddened areola. Six months' duration. Second point of ulceration beginning at lower periphery of the neoplasm. (Martin.)

Malignant Growths.—Malignant growths of the scalp may be *primary* or *secondary*. The *primary cancers* are either chronic *superficial epitheliomas* or *deep* aggressive tumors.

The *superficial cancers, epitheliomas* or *rodent ulcers* are not rare on the scalp, and are more frequent than the deep variety. They are found almost entirely in advanced or middle life, and develop as a rule on some preëxisting benign lesion, such as a wart, mole, adenoma, or a sebaceous or sweat gland, old ulcer or senile seborrhea. Chronic irritation of one of these latter lesions seems to be the cause of the malignant degeneration in most cases. Some cases develop in apparently normal skin, without a preëxisting lesion. The forehead, in the region of the eye or temple, is the favorite location. The breaking down of the first small nodule in the skin results in an ulcer which is shallow and unevenly rounded, and which has a more or less indurated border. This border may be slightly elevated, uneven and somewhat undermined. The surface usually bleeds on slight irritation. There is a

Fig. 62.—Superficial epithelioma of the scalp. (Hertzler.)

tendency at times for the ulcer to become covered temporarily with epidermis, and sometimes scar tissue forms to such an extent as to draw the surrounding skin into folds. In the early stages, even for years, the ulcer may be freely movable with the skin, but later, with deeper invasion, it becomes fixed.

While these cases are chronic from the beginning, and sometime are small at the end of five or ten years, with no *apparent* metastases, they may at any time become vicious and rapidly invade the surrounding structures, destroying even the underlying bone.

The *deep cancer* while less frequent on the scalp than the superficial is a much more formidable type of tumor, as it quickly invades the surrounding tissues in all directions, and early spreads to the neighboring lymph nodes and to more distant parts of the body. In this variety the tumor element is a prominent feature from the beginning and ulceration is often deep.

Skin cancer sometimes grows as a *papillary* tumor, originating either in a preëxisting benign wart, or developing as a malignant papilloma from apparently normal skin. Horns may be present in these cases.

Differential Diagnosis.—The differential diagnosis of the skin cancers calls for a consideration of *syphilitic* and *tuberculous ulcerations,* and sometimes the ulcers of *blastomycosis.* In the latter three conditions the lesions are usually multiple, and they lack the induration so characteristic of most cancers. For further details see special headings. The Wassermann and tuberculin tests are helpful here; and the finding of the blastomyces in the smears would settle the diagnosis in the case of blastomycosis. Too often it is the change in character which a preëxisting benign lesion has assumed that is misunderstood. It is a singular fact that cancers on the surface of the body, where they can be seen and felt, are very frequently allowed to progress to an incurable stage before the correct diagnosis is made. When a wart begins to grow larger or ulcerates, or when nodules develop in a chronic ulcer, malignancy should always be suspected, and a positive diagnosis made at once.

In all doubtful cases, and these are usually the early cases, the lesion, if not too large, should be completely excised, and the diagnosis made from the frozen section. If the surface ulceration is quite extensive and the diagnosis still in doubt, excision of a suspicious piece will allow the diagnosis to be made from the frozen section, the wound in the meantime being packed with Harrington's solution No. 9.

Treatment.—The treatment for skin cancer is complete excision of the growth and the lymph nodes most likely to be involved. The latter should be excised *en masse,* with the surrounding fat, regardless of whether they are palpable or not. It is, however, impossible to deal thus radically with the parotid lymph nodes unless one is willing to sacrifice the facial nerve. Many cases confined entirely to the skin, and without glandular involvement, have been apparently cured by the use of the *x*-rays or radium, but most of these could have been excised without resulting deformity. In inoperable cases the *x*-ray, radium, caustic pastes and the cautery will often be of some service in retarding the superficial growth and in keeping down hemorrhage and infection.

Sarcoma of the Scalp.—Sarcoma of the scalp may occur at any age or in any region. It may be *primary* in the connective tissue of the apparently normal skin or fascia, but it usually arises *secondarily* in warts, moles or vascular nevi. Grossly they are divided into two groups: The *nodular,* aggressive tumor which infiltrates the surrounding tissues, and the *warty* type, which grows more as a papilloma. The nodular type may or may not be markedly elevated above the surrounding skin surface, having edges in some cases like a mushroom, but it is always a more or less formidable tumor invading the surrounding tissue and leading to extensive metastases to the nearest lymph glands and to the various organs of the body. The overlying skin, especially in the deeper varieties, may remain intact for a long time. If ulceration occurs it is more superficial and smooth, rather than deep and crater-like as in carcinoma.

FIG. 63.—Sarcoma of scalp. Death a few months after photograph was made. (Dr. W. L. Rodman's case.) Presbyterian Hospital. (Ashhurst.)

FIG. 64.—Endothelioma of the scalp. (Hertzler.)

The *warty sarcomas* present themselves as bleeding fleshy warts, whether they develop primarily as such or secondarily in a papilloma. They are found chiefly in advanced life and their clinical course is much more benign than that of the nodular variety.

Melanosarcoma, arising from a pigmented mole, is in a class by itself because of its viciously malignant course. It may develop as a very aggressive nodular mass or as multiple pigmented nodules in the skin, in any event leading to early metastases through the lymph and blood channels to the glands, viscera, bones or skin. The *pigment* in both the original tumor and the metastases is the striking feature.

Angiosarcoma, which may exist as a relatively hard tumor or as a soft *pulsating* variety, may arise from the endo- or perithelial cells of hypertrophied bloodvessels.

Endothelioma, i. e., lymphangio-endothelioma, is not only rare in the scalp, but it is impossible to recognize it clinically. It consists of a slow-growing circumscribed nodule with very little tendency to metastasis and hence is a relatively benign tumor.

Diagnosis.—Sometimes it is necessary to *differentiate* sarcoma from a rapidly developing *gumma.*

Prognosis.—The prognosis of the above mentioned forms of sarcoma varies according to the type of tumor we are dealing with. The type described as nodular offers a very bad prognosis, the warty variety a relatively good prognosis, while in melanosarcoma and all very vascular sarcomas the outlook is exceedingly bad. Endotheliomas are relatively benign.

Treatment.—The treatment in all cases, if not inoperable, is wide excision. In the inoperable cases, and in certain postoperative cases, it is well to try the *x*-ray, and also Coley's mixture of the toxins of erysipelas and bacillus prodigiosus. The *x*-ray should be intensive and should be given daily for a period of six days. This procedure should be repeated every few weeks for a period of several months.

THE CRANIAL BONES.

WOUNDS OF THE CRANIAL BONES.

Wounds of the cranial bones are usually classified as *incised, punctured* and *contused wounds.* Naturally the character of the wound will depend to a great extent upon the shape and size of the contusing surface, as well as upon the force and direction of the blow.

Incised Wounds.—A saber cut, or a blow with the sharp edge of a hatchet, if delivered with force squarely on the vault, may result in an incised wound of the bone with no surrounding fragmentation or fracture, except possibly a fissure extending out from either end of the cut. The same blow, with less force, may cause an incised wound of the outer table with more or less fragmentation of the inner table. A powerful blow with the same instrument in a tangential direction may slice off a flap of bone. Though these cases are all open to inspection it is sometimes difficult to determine accurately the extent of injury to the internal table or the underlying soft parts. The prognosis depends not only upon the latter, but upon the presence or absence of infection.

If the history of the injury, the appearance of the wound, and the lack of symptoms make it reasonably certain that the wound is non-penetrating, disinfection, partial suture and drainage of the wound, is probably all that is necessary. If the wound has penetrated the cranium, disinfection, trephining, removal of foreign bodies and drainage are always indicated. The drainage should extend through the dura if the latter has been opened.

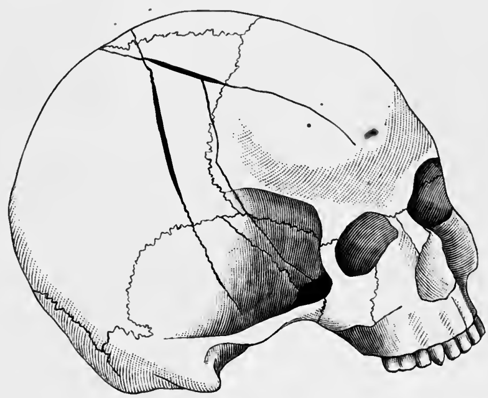


Fig. 65.—Sword cut; fissured fracture.

Punctured Wounds.—Punctured wounds are similar to incised wounds in many respects, with these differences, however: that they are not so freely open to inspection, and that, if not operated, drainage is poor. Consequently they are more liable to serious deep infections. Moreover, the penetrating body is liable to be broken off.

Every case calls for early disinfection, trephining, removal of foreign bodies and drainage. The drain should always extend to the cortex if the dura is not intact.

Contusions.—A subcutaneous contusion of the skull always carries with it the question as to whether one is dealing with a contusion or a fracture.

Diagnosis.—In making a probable diagnosis one has to consider the force and direction of the blow and the size of the contusing surface, as, for instance, a swift blow from a body with a small surface, like a hammer, delivered squarely on the head, is very likely to have caused a fracture. Under such circumstances one is justified in making an accurate diagnosis by inspection and palpation through an exploratory incision. On the other hand, with the history of a less severe blow, especially if delivered on a tangent, and in the absence of intracranial symptoms, expectant treatment may be all that is called for. One should always be on his guard lest he be led into the diagnosis of depressed fracture by the firm ring of reactionary edema so often noticed in contusions with hemorrhage into the soft external coverings. Distinct intracranial symptoms, such as those of compression, will demand active exploration even though the injury itself has the appearance of being a simple contusion.

Prognosis.—The prognosis in all head injuries, especially in those of advanced years, and in those with distinctly bad family histories, from the standpoint of the central nervous system, should allow for possible subsequent mental symptoms, epilepsy, etc.

Osteomyelitis may possibly develop later on as a result of diminished local resistance, but this is not very frequent.

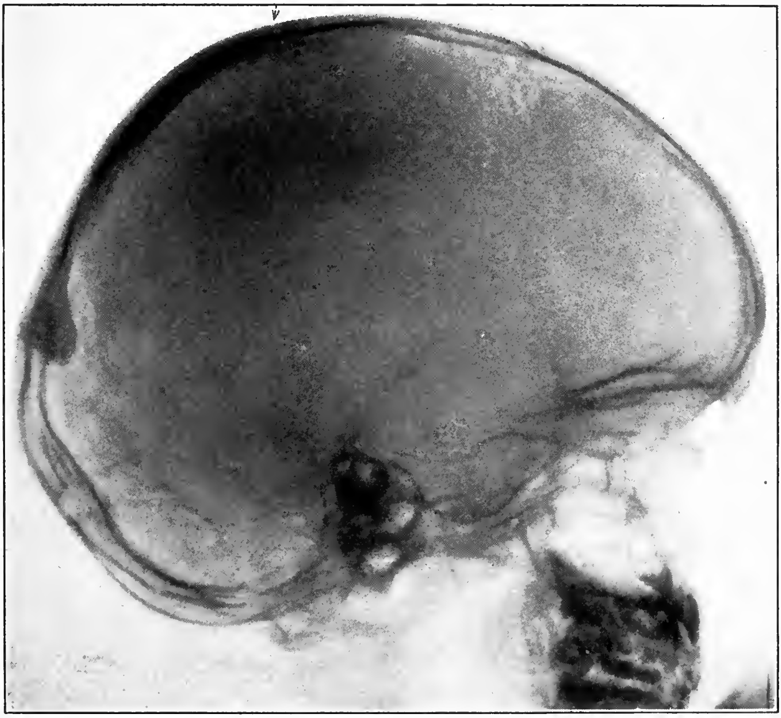


FIG. 66.—Fissured fracture, x-ray findings confirmed at operation. (H. P. Knapp.)

Skull Fractures.—The diagnosis of a fracture of the skull in the absence of an open wound, is sometimes exceedingly difficult, or even impossible. A fracture may exist without bony deformity and with no symptoms referable to the brain or cranial nerves. On the other hand cerebral symptoms may follow an injury to the skull without fracture; hence they have more to do with prognosis than diagnosis. Tumefaction of the scalp may completely obliterate an underlying depression, and even palpable depressions may not be of recent origin. In the latter case an unconscious patient could not explain that his depression was due to an old injury, disease or deformity. Contusion with hemorrhage into the soft coverings and certain infections in the scalp may so closely simulate fracture with depression as to deceive capable, but somewhat careless, diagnosticians. A contusion at one point may lead to a fracture or cerebral involvement at another point. The *x*-ray examinations may be of great assistance, and even the careful use of the stethoscope, combined with percussion, is considered by some as being helpful in some cases.

It is no longer permissible to explore every simple contusion merely to determine the existence of a fracture. The exploratory incision is to be made on the grounds of cerebral injury rather than those of fracture, except possibly in those cases where the history of the injury, combined with suggestive local findings, render it probable that a bending fracture has occurred.

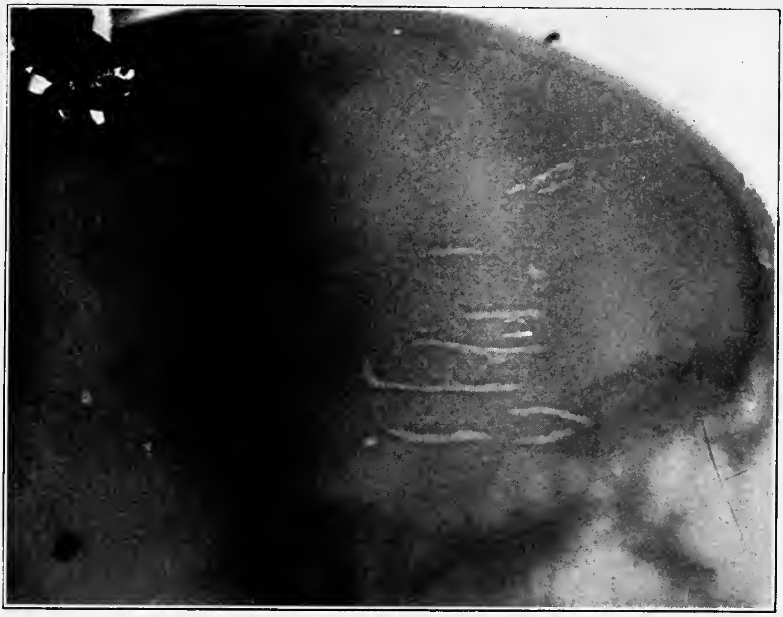


Fig. 67.—Fracture of vault. (Hartung and Huber.)

Palpation and the *x*-ray are practically our only means of diagnosing *simple*, or closed, fractures. For this reason the uncomplicated *fissured fracture* will often go unrecognized. A probable diagnosis of this condition would be made if there existed a persistent tenderness along a definite line, especially if the pain were noticeable on both direct and indirect pressure. Such a diagnosis, however, would be of little consequence.

If, following an injury, there were found under the scalp a collection of fluid that pulsated with the brain, and which also became tense with increased intracranial tension, as in coughing, crying, sneezing, etc., a fracture with rupture of the dura would be diagnosed. The fluid might be blood or cerebrospinal fluid. The latter is most frequently

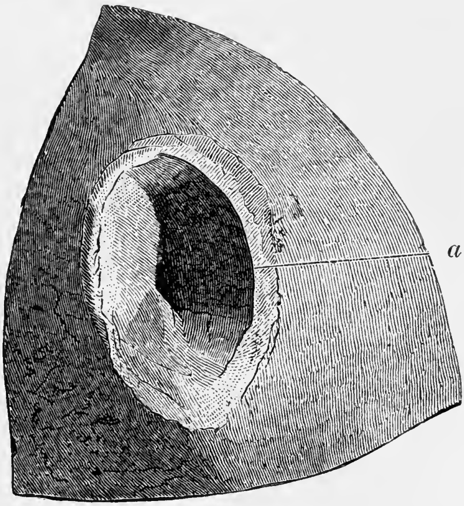


FIG. 68.—Circumscribed depressed fracture, outer surface.

found in the fractures of the infant cranium, and is spoken as a *meningocele spuria*. Likewise a collection of air beneath the pericranium, *pneumatocele capitis*, following injury, means fracture through an air-containing sinus.

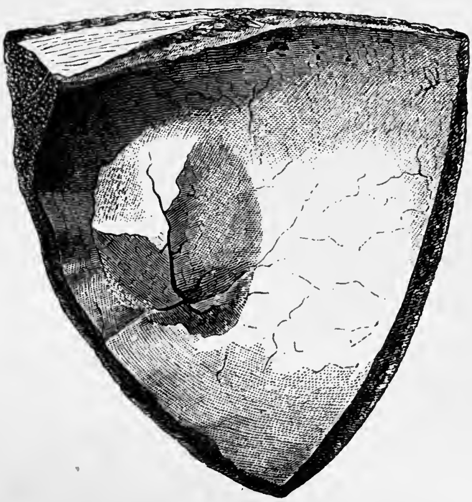


FIG. 69.—Circumscribed depressed fracture, inner surface.

The *simple depressed* and *comminuted fractures* of the vault can usually be easily recognized by palpation alone, especially if seen directly after the injury. As stated in a previous paragraph the history of the accident, combined with suggestive local findings, will often make the existence of a fracture most probable. Thus when a patient

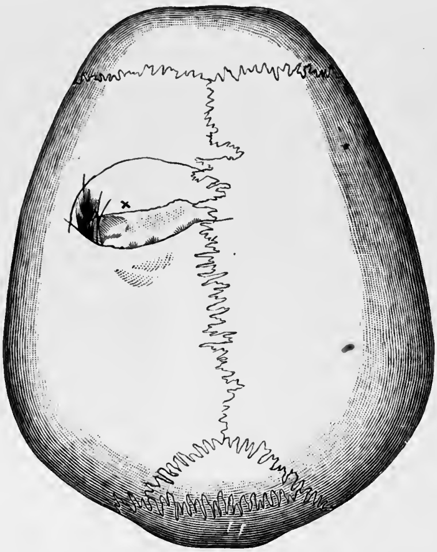


Fig. 70.—Circumscribed fracture with inclusion of hair.

receives a powerful blow with a hammer squarely on the vault a bending fracture with comminution of the internal table is almost certain to be present.

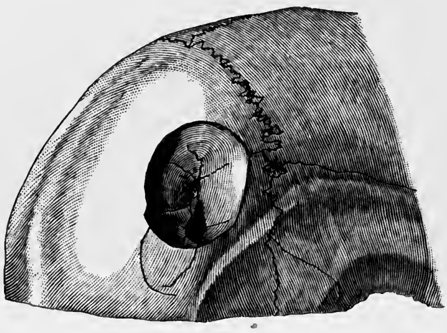


Fig. 71.—Circumscribed depressed fracture.

Compound fractures of the vault with anything more than a small skin wound will usually be both visible and palpable. The only danger here would lie in carelessly mistaking a rough suture line, Wormian bones, senile atrophy or the irregularities of an old osteomyelitis for fracture.

Having made a diagnosis of *fracture of the external table,* whether simple or compound, it is not always possible to know definitely whether the internal table is fractured or not. Most of the fissures involve both tables, and all steep depressions, except possibly those over the air-

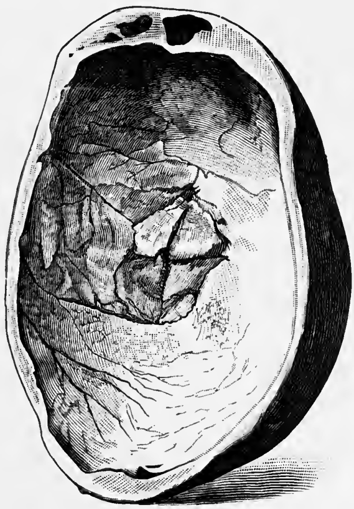


FIG. 72.—Fracture of internal table.

containing sinuses, not only involve the inner table, but the latter is broken more extensively than the outer table. *Punctured fractures* practically always involve both tables, the inner more than the outer. Gunshot injuries will be mentioned later. *Fracture of the internal table*

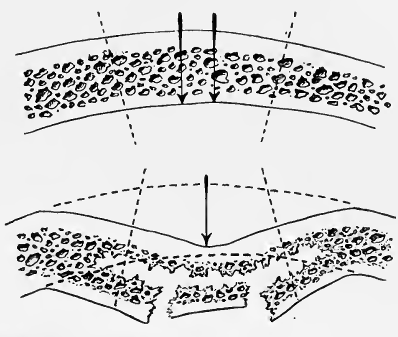


FIG. 73.—Teevan's diagram to show that the inner table often is more extensively damaged than the external, because it is in the line of extension. (Ashhurst.)

alone is to be surmised when a sharp local impact over an area where diploë exists, though showing no external fracture, results in local cortical irritation. A good skiagram might possibly establish a positive diagnosis.

Fractures of the Base.—Basal fractures are in a class by themselves because of the mechanism of their production, their serious nature, the fact that they nearly always traverse some cavity containing infectious germs, and because of the fact that the fracture cannot be palpated. The symptoms on which the diagnosis is based are mostly indirect.

The contusing violence here is of a diffuse character, *i. e.*, instead of the sharp impact over a small surface as we find in bending fractures, the force is more of a crushing, compressing violence, covering a broader area and tending to press the poles of the skull together. As examples of such violence one might mention a blow from a falling timber, a fall from a height striking on the head, etc. Any force which presses the opposite poles together tends to burst the skull along the lines of the meridians. The direction of the meridian or fracture depends upon

FIG. 74.—Diagram showing the usual course taken by fissured fractures of the base of the skull.

the direction of the force or compression. As the base of the skull offers the least resistance to this bursting effect, the line of fracture will be found more frequently here than over the vault.

Symptoms.—As to the symptoms which lead us to infer that a fracture of the base has occurred, one of the most important is *hemorrhage,* free or into the tissues, with, however, definite qualifications. Bleeding may occur freely into the nose or nasopharynx or through the ear. Here it is necessary to exclude local injury to the nose, mouth and throat or to the extracranial parts of the ear. Very slight injuries may cause bleeding from the nose, especially in certain individuals, but if the hemorrhage from the parts is associated exclusively with injury to some part of the cranium, it takes on a distinct significance. The bleeding from the nose in cases of fracture of the anterior fossa comes usually from a break through the ethmoid, while in middle fossa fractures it generally comes through the sphenoid sinus. In some cases it reaches the nasal cavity through the Eustachian tube, having come from a fracture through the middle ear without rupture of the drum.

When considering the local causes of hemorrhage from the nose and nasopharynx one must remember the possibility of penetrating wounds of the base resulting from falls upon a pointed stick or weapon.

A free hemorrhage from the ear in case of injury to some other part of the skull is probably due to a fracture of the base involving the middle ear, usually with rupture of the drum membrane, though the latter may remain intact, the blood then escaping through the roof of the canal. A very mild hemorrhage following a direct trauma may mean merely injury of the extracranial parts of the ear.

Hemorrhage into the tissues may be due to a contusion without fracture, as seen in the ordinary black eye, or it may follow a fracture. In the former case it appears as a black and blue swelling promptly after the injury, whereas in the case of fracture it makes its appearance late, at least hours afterward, but usually one or two days after the injury.

Ecchymosis in or about the orbit, like hemorrhage into the nose, may result immediately from slight local injuries, or from straining, as in severe fits of coughing, but if due to fracture it comes not only late, but is more extensive. If a large vessel, like the cavernous sinus or the orbital branch of the middle meningeal, were ruptured, the infiltration of the tissues and the appearance of the ecchymosis would be more rapid. According to the location of the fracture the ecchymosis may appear in the upper lid, beneath the conjunctiva, or in the retrobulbar fat. In the latter case exophthalmus might be a result, the degree and the time of appearance depending upon the amount of hemorrhage and the size of the vessel involved. *Pulsating exophthalmus* with the eyeball pushed outward as well as forward, would indicate injury of both the internal carotid and cavernous sinus with a resulting *arteriovenous aneurysm.* In this event the other signs of arteriovenous aneurysm would be present.

Ecchymosis appearing in the region of the mastoid or temple several days after a head injury is usually indicative of a fracture of the middle fossa; likewise a late appearing ecchymosis in the occipital region or neck may point to fracture of the posterior fossa.

Unquestionable signs of fracture are the escape of cerebrospinal fluid and brain substance. The latter is found only in case of severe fractures, while the former may occur in either the mild or severe cases. The cerebrospinal fluid has been noticed in only about 5 per cent. of cases of fracture of the base. It may be small in amount or very free. In one of my cases the escape was so free that large sterile pads had to be kept over his ear. During coughing or sneezing the fluid was noticed on several occasions to spurt a distance of two feet from the patient. The peculiar feature of this case was that the young man, who had been thrown from a delivery wagon, striking on his head, sustained only a moderate concussion, and scarcely felt sick enough to remain in bed.

In this particular case the fluid was noticed promptly after the accident, though in the ordinary case it is not noticed until hours afterward, at any rate not until the free hemorrhage clears up. It may make its first appearance days after the injury. The flow may last from a few hours to a week or more. Cerebrospinal fluid, like hemorrhage in basal fractures, may find its way into the nose through fractures of the ethmoid or sphenoid, or it may come down the Eustachian tube from the ear. It contains large quantities of chlorides, but no albumin unless mixed with blood or exudates. The exudates, on the other hand, contain only a small amount of chlorides, while they possess a comparatively large amount of albumin. If the quantity of clear fluid escaping from either the ear or nose is small its source cannot be determined without a chemical examination. If it is large, and especially if the rate of flow depends upon the variations of intracranial pressure, there can be no question about its being cerebospinal fluid.

Symptoms due to *involvement of the cranial nerves* possess only a relative diagnostic value because they may represent either a peripheral or central lesion with or without fracture. They are often of distinct service, however, in locating the seat of fracture, especially if the grouping of the symptoms is studied. Thus paralysis of the seventh, eighth and sixth nerves determines the course of the fracture through the petrous process (von Bergmann). The time of the onset of the symptoms, and the extent of the paralysis, will materially aid in establishing the nature of the lesion, whether rupture, compression from hemorrhage or inflammatory exudate, etc. The nerve most frequently involved is the facial because it traverses a long, tortuous canal in the petrous process which is so often the seat of fracture. The sixth ranks next to the facial in frequency of involvement. In fractures of the anterior fossa the nerve most frequently injured is the olfactory because of the usual involvement of the fragile cribriform plate of the ethmoid. The second and third nerves, and the first division of the fifth may be more or less involved. In middle fossa fractures the nerve most frequently injured is the seventh. As stated before, the eighth is frequently implicated with the seventh. The second and third divisions of the fifth nerve are seldom injured. Fractures through the cavernous sinus may involve the first division of the fifth, the sixth, third and fourth nerves. In fractures of the posterior fossa, involving the jugular foramen, the ninth, tenth and eleventh nerves, which pass through this foramen, are only occasionally injured.

Fracture of the base is often associated with fracture of the vault, probably in about three-fourths of the latter; and fissure of the vault is frequently found in cases where the basal injury predominates. The character of the injury, whether a localized sharp impact or a diffused compression, is a decided factor in the determination of the kind of fracture, whether bending or bursting. The location of the impact and the direction of the force determines to a great extent the general direction of the line of fracture. For these reasons a detailed history of the accident can often be of distinct assistance in the diagnosis.

After all, the diagnosis of fracture in its various forms and locations is of service only insofar as it enables the surgeon to recognize and treat, or to prevent, associated lesions of the intracranial structures. The important features, therefore, *i. e.*, lesions of the brain, its coverings, etc., will be discussed later on under their proper headings.

Prognosis.—The gravity of skull fractures can be appreciated when one realizes that approximately one-third of all cases prove fatal, largely because of the violence to the intracranial structures. As practically all basal fractures and the majority of vault fractures are compound, the possibilities of early or late infection, thromboses, etc., become manifest. Then, too, there is always the remote possibility of degenerations, cortical irritations, etc., leading to epilepsy, insanity and the various neuroses. The prognosis then depends to a great extent upon the surgeon's ability to cope with the existing conditions and upon his ability to prevent the remote pathology. His unavoidable limitations in these respects, especially in basal as compared with vault fractures, can be better imagined than described.

Rawlings in a study of the records of over 300 cases came to the conclusion that the temperature chart of the patient is of great value in formulating a prognosis in cases of head injuries. He concludes that for a variable period of time after the injury the temperature is subnormal, this being the period of shock. Death may occur during this period, or reaction, accompanied by a rise of temperature, may set in. If the temperature remains normal the prognosis is good. If it rises moderately and then "marks time" the prognosis is held in abeyance as the case has reached its crisis; a fall to normal now indicates a recovery, while a further rise usually points to a fatal termination. A rapid and progressive rise of temperature (6° or 8° in a few hours) is usually an indication of early fatal termination. Laceration of the brain was present in the majority of cases with marked temperature.

Treatment.—The treatment of all of these cases has for its object the conservation of the functions of the brain rather than any special treatment of the bony lesion itself.

In simple fractures of the vault interference is warranted (*a*) on definite indications of bony deformity, such as depression regardless of symptoms, (*b*) by the evidence of localized compression whether extradural or intradural, (*c*) by the evidence of localized cortical irritation. In special cases subdural drainage may be indicated on the grounds of general compression in case of edema. Those cases associated with contusion and general cerebral irritation do not call for operation. In any case operation should not be performed during profound shock.

All *compound fractures of the vault* are operative, if for no other reason than primary wound disinfection. Especially is this the case in punctured fractures, for evident reasons. In all these cases adequate drainage to the cortex or dural opening is indicated, and free drainage must likewise be provided for the blind pockets under the scalp. A torn dura, like a torn scalp, may be partially sutured. Dirt ground into the tissues, whether soft tissues or bone, must be cut away with scissors or bone instruments.

Loose fragments of bone, large or small, free or impacted, may be retained in simple fractures. In compound fractures, however, they had better be removed unless they have pericranial attachments, or unless the wound, in the judgment of the surgeon, is reasonably clean. In many cases they can be retained and removed later if necessary.

In fractures of the base operative interference is seldom called for, and then it is only on the ground of compression from hemorrhage or edema, or because of infection. Middle meningeal or lateral sinus hemorrhage may call for trephining in order to arrest the bleeding. General oozing or cerebral edema may lead to such a degree of compression as to demand relief through subtemporal drainage of the subdural space.

The only justifiable treatment in the average case is the so-called expectant treatment, viz., absolute quiet, rest, through sedatives if necessary, ice-cap, elevation of the head of the bed, elimination through cathartics, normal salt solution, etc. Little can be done to avoid infection through the open connection between the cranial cavity and the air sinuses into which the fracture has extended. One can, however, at least avoid the added dangers of meddlesome irrigation, spraying and plugging of the ear and nose. In the case of the ear we must be content with gentle cleansing of the external ear and canal with a swab soaked in a 1 per cent. lysol solution, and the insertion in the canal of a slender, very loosely applied strip of gauze for drainage. A sterile pad should be applied externally.

If the case does not die during the first forty-eight hours the prognosis, so far as recovery is concerned, is fairly good, but one should always be on the lookout for symptoms calling for justifiable interference. Rest in bed for at least one month, and avoidance of all work or mental activity for at least six months, should be insisted upon.

Gunshot Wounds of the Skull.—Gunshot wounds of the skull, like fractures of the base, are in a class by themselves, and consequently are separately described. Of all the influences governing the effects of this class of injury the chief ones are the physical properties of the skull contents and the velocity and physical properties of the missile. The semi-fluid character of the skull contents allows the active force of the bullet of high velocity to be transmitted in all directions, in other words to explode. As the velocity diminishes the explosive effect grows less until finally the results may become no more nor less than those of a punctured wound, or a mild bending fracture from a spent ball. A soft bullet, such as is used in the ordinary pistol of civil life, and the partially "jacketed" bullet with the soft nose, such as is used in hunting for big game, flatten out, become mushroomed, when they strike an object, and so tear frightful holes in the tissues. Thus with a low velocity their destructive effects on the skull and brain may be just as great as those of the full-jacketed bullets of higher velocity. Furthermore the soft bullet of low velocity is more apt to become fragmented and lodge in the skull or brain. The dum-dum bullet with high initial velocity combines the action of the deformed missiles with that of the explosive or hydrodynamic force.

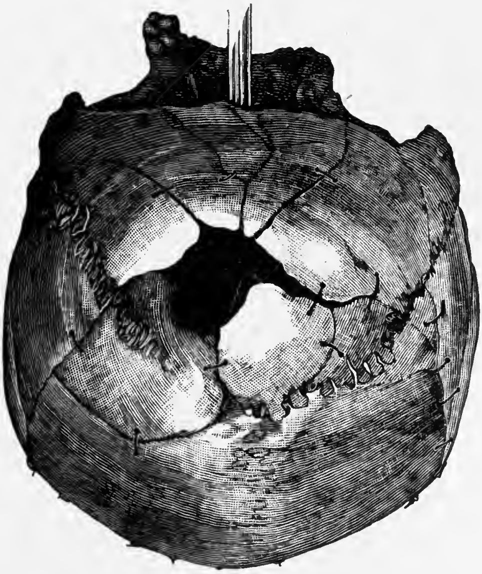


FIG. 75.—Gunshot fracture of skull, posterior view.

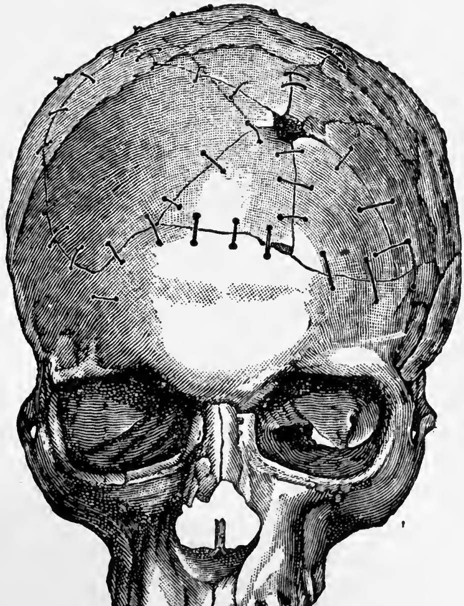


FIG. 76.—Gunshot fracture of skull, anterior view.

The injuries of the dura mater correspond somewhat in extent with those of the skull. At the wound of entrance the inner table is always more extensively shattered than the external, the opposite obtaining at the wound of exit.

These fractures are naturally all compound with more or less comminution and displacement of fragments or loss of substance. Many have bursting fissures extending into the base. According to circumstances the fracture may be a perforating, penetrating, gutter or simply an inbending fracture. Because of the violence of the intracranial injuries leading to increased tension, these cases are very apt to present extrusion of the brain substance at the points of fracture. Nerves are sometimes implicated without the skull cavity having been penetrated. Notable examples of this are the destruction of the optic nerves in attempted suicides.

Diagnosis and Prognosis.—The practical points in the diagnosis and prognosis concern the immediate and late pathology of the intracranial contents and cranial nerves. The immediate symptoms due to the destruction of brain tissue, and hemorrhage, and the later symptoms of sepsis and brain irritation will be discussed later on.

Skiagraphs may be of service in defining more or less of the bone lesions, and also in locating the bullet or its fragments.

Though the bullet itself is to be looked upon as free from infection, it frequently opens up a track through septic cavities, or it may carry with it pieces of hair, cap, etc., that are not sterile.

Nearly half of the cases die immediately, and a further percentage die as a result of unavoidable subsequent complications.

Treatment.—The treatment is unsatisfactory as the destruction of the brain tissue in the path of the missile or within the reach of the "active force" of the bullet with high velocity cannot be repaired. Likewise no amount of skill can regularly eliminate infection from a fissured base; nor can foreign bodies, deeply embedded, be extracted without further damage. Even an early leptomeningitis at the base can rarely be checked.

Meddlesome interference, such as probing and irrigating and unnecessary operating, should be avoided. Dry shaving and painting the site of the scalp wound with tincture of iodin is all that is necessary in some cases; in others operative interference is indicated for the removal of pieces of bone or foreign bodies imbedded in the surface of the brain. If drainage should be indicated, as in cases where foreign bodies, such as bits of clothes, hair, etc., have been lodged near the brain surface, it should not extend deeper than the subdural space, as brain drainage is very unsatisfactory, and may be very harmful. Complications, such as hemorrhage, cerebral edema, infections, etc., are to be watched for, and met, as described in fracture of the base. A bullet which has lodged in the cranial cavity is to be regarded as aseptic, and there should be no attempt at its removal unless it is in a readily accessible position, or unless it is causing symptoms of brain irritation.

Skull Injuries in Infants and Young Children.—Vault fractures or indentations are occasionally seen in the newborn as a result of difficult labor or instrumental delivery. Even fracture of the base has been observed. Indentations are also seen in very young children as the result of falls. To admit of this the skull bones must necessarily be thin and very elastic.

These cases are to be treated on the same general principles as fractures in adults, except that the indentation should be allowed a week or ten days to undergo spontaneous reduction, the usual occurrence. If this latter does not take place, the bone should be forced into its proper position through the use of some smooth instrument, like a Kocher's director, inserted through a small opening at the margin of the depression.

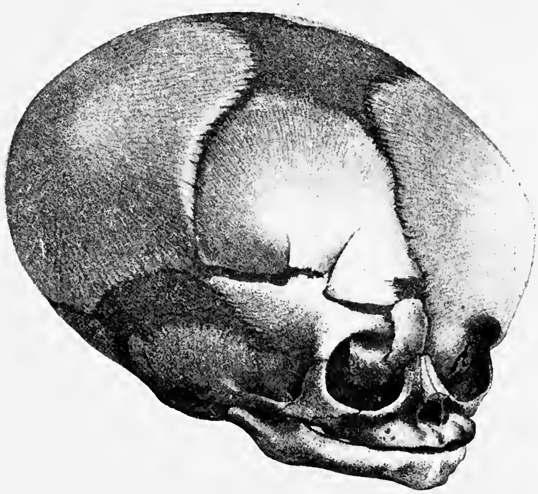


FIG. 77.—Fracture of right frontal bone in a newborn infant, fracture extending into orbit.

AFFECTIONS OF THE CRANIAL BONES.

Atrophy.—Atrophy of the cranial bones is of interest chiefly from the standpoint of diagnosis. It is usually a local process, due to local pressure, to inflammatory changes, or to a combination of local pressure and constitutional disease. It may occur as a more or less local process in the form of the so-called eccentric atrophy of old people, the cause of which has not been determined.

Intracranial pressure under normal conditions shows its effect in the depressions for the Pacchionian granulations, and the grooves for the venous sinuses and the middle meningeal arteries. Pathologically, pressure atrophy is found over intracranial tumors situated immediately beneath the bone. In cases of prolonged increased intracranial tension the venous stasis may lead to extensive atrophy through dilatation of the veins of the diploë, or it may show itself chiefly at the site of the emissary vessels. The pressure in the case of tumor may lead to spontaneous decompression by perforation of the skull.

Extracranial pressure, as from tumors, notably dermoids and angiomas, may lead to atrophy of the underlying bone, but this is rare, because the soft scalp admits of easy expansion in the direction of least resistance. Atrophy has followed pressure from cephalhematoma.

Senile or excentric atrophy, found chiefly in old men, is a bilateral patchy atrophy, occurring in the region of the parietal protuberances. Its cause is unknown, but König suggests that it is the result of involution changes. The atrophic process starts in the diploë and extends outward, leading to excavations which are sometimes mistaken for fractures. It is a rare affection.

Fig. 78.—Craniotabes, rachitis.

Osteomyelitis, especially of the tuberculous type, may lead to a rarefaction of the bone.

The *atrophy of rickets* is the most frequent variety met with in the skull bones. These spots of atrophy are found chiefly in the parieto-occipital region and are known as *craniotabes.* The bone at these points may become as thin as paper, or even disappear altogether, so that, as König says, the occiput may feel like a soft abscess.

Accompanying the absorption of the bone there are excessive deposits of soft osteoid tissue in the frontal and parietal regions, which, with the flattening of the occiput from pressure, give to the head the characteristic cuboidal appearance. The fontanelles are larger than normal, and may remain open until the third year. The edges of the sutures are usually very soft. The craniotabes usually disappears before the end of the third year unless complications are present. The deposits of osteoid tissue in the frontal and parietal regions do not disappear, but become very hard as recovery takes place.

The usual constitutional symptoms and other skeletal changes are present.

Diagnosis.—The diagnosis is usually easy, but there are other diseases presenting as part of their pathology areas of thin bone or deformed cranial bones, large fontanelles, soft suture edges, etc. Among these we find *hydrocephalus*, which may coexist with rachitis, *congenital fragilitas ossium* or *osteogenesis imperfecta, chondrodystrophia* or

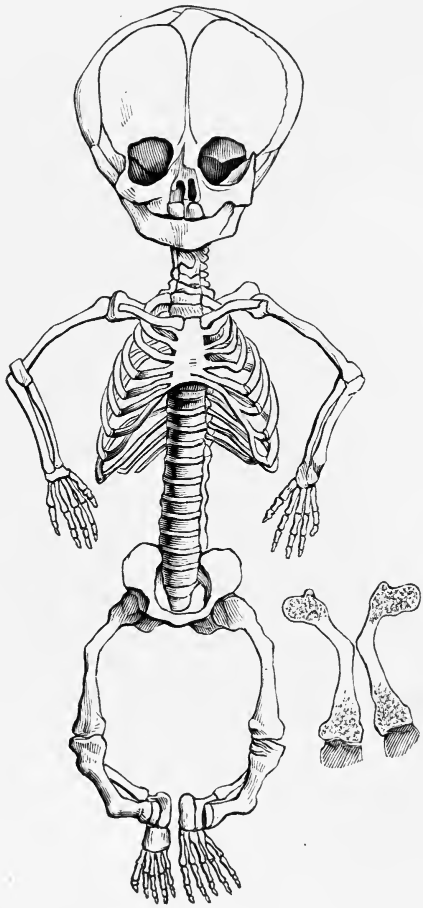


Fig. 79.—Achondroplasic skeleton.

achondroplasia (*fetal rickets*), *congenital syphilis, cretinism,* etc. The associated lesions and x-ray findings in the long bones will help to differentiate most of these conditions, all of which are rare except congenital syphilis and hydrocephalus.

In *achondroplasia* and *congenital fragilitas ossium* there is a lack of development rather than an atrophy of bone. In the former case the pathology is confined mostly to a premature union of the epiphyses of the long bones, the skull usually being very little affected. The infant early has the characteristic appearance of a dwarf. The head

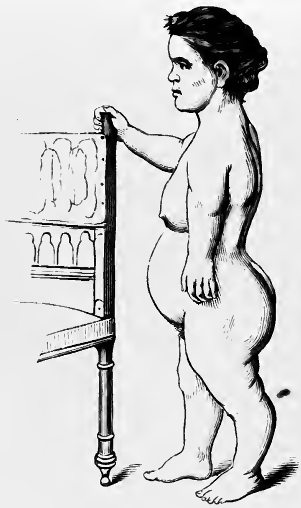


Fig. 80.—Achondroplasia.

Fig. 81.—Osteopsathyrosis.

changes in congenital fragilitas ossium are often very marked, especially at the back, where the bone may be almost entirely wanting. The fragility of the bones throughout the body leads to frequent fractures, even intra-uterine.

Treatment.—The treatment is entirely along general lines. Soft areas in the skull should be protected from pressure by ring pads, or inflated ring cushions.

Carl Beck,[1] in an interesting article on Osteopsathyrosis, refers to Bossi's clinical and experimental work in connection with adrenalin in the treatment of osteomalacia. He says, "To me the theory of Bossi seems the most probable that the suprarenal capsules have an influence upon the regulation of the salt deposits in bones, and that the absence of the particular secretion is responsible for the riot of the cells carrying on the absorption of lime salts. It seems to be borne out by experiments as well as by the good results obtained by Bossi and others, and also by myself, by the use of adrenalin."

Bossi found in his experiments on sheep that removal of the suprarenal capsules was followed by changes almost identical clinically and pathologically with osteomalacia, and thus established the connection between growth of bones and the suprarenal capsules.

Beck then cites the case of a young girl who developed a softening of most of the bony skeleton, chiefly of the long bones, with a great tendency to fractures; and very little disposition to healing. "With the injection of adrenalin the pathological condition gradually shows clearly an increase of lime salts and gradual healing." He injected ten to twelve drops of the 1 to 1000 solution daily for twenty-five days. Relief from pain was noticed after the first injection.

Emil Beck, in an article read before the Chicago Surgical Society, cited a case of cystic degeneration of bone cured by the use of adrenalin.

A number of the *cranial hypertrophies*, separately described because differing in many respects, seem to possess enough fundamental similarities to warrant the conclusion that they are etiologically related. Moreover, one form may be associated with another in the same individual. The chief diseases here referred to are acromegaly, leontiasis ossea, gigantism and osteitis deformans.

Acromegaly.—Acromegaly is a systemic disease of a distinctly trophic character, involving especially the osseous system, though the soft tissues are more or less involved. The most striking feature is general hypertrophy of the bony skeleton. The bones of the skull take on the form of a diffuse hyperostosis, those of the face, especially the lower jaw and the supra-orbital ridges, becoming very heavy and prominent, giving the face the appearance so characteristic of the disease.

The onset of this condition occurs usually in late youth or early adult life, and tends to a fatal issue in from ten to thirty years. Most cases are associated with some pathology of the hypophysis cerebri, though cases of acromegaly and allied conditions have been reported in which the autopsy showed no lesions of the hypophysis; and, on the other

[1] Surg., Gynec. and Obstet., 1910.

Fig. 82.—Acromegaly.

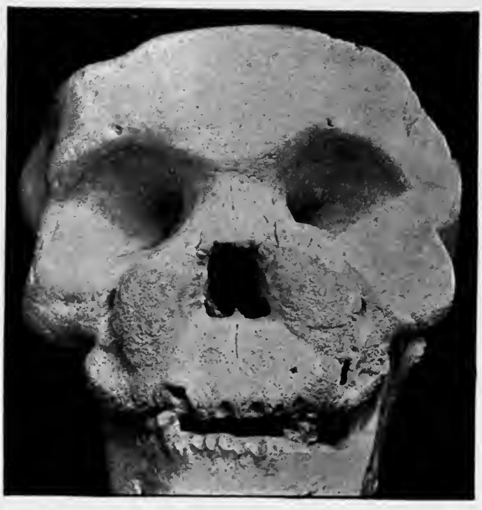


Fig. 83.—Leontiasis: skull of a Chinese woman.

hand, lesions of the hypophysis have been found in cases with no sign of trophic changes in the bony skeleton.

Treatment.—Operation may possibly prove of benefit in those cases where the symptoms and x-ray findings point to disease of the hypophysis.

Gigantism.—Meige[1] states that: "When the disease commences in youth we get a case of gigantism; when in adult life acromegaly; if commencing in youth and continuing into adult life we get a combination of the two. Acromegaly never precedes gigantism. Acromegaly sets in during the course of about one-half of the cases of gigantism." Woods Hutchinson[2] states that we are "justified at least in the tentative conclusion that acromegaly and gigantism are simply different expressions of one and the same morbid condition."

The average duration of life is seldom over twenty years.

Leontiasis Ossea.—Leontiasis ossea is a chronic disease of unknown origin leading to marked diffuse thickening and sclerosis of the bones of the face and cranium. Either or both sets of bones may be involved. Bassoe[3] states that "Baumgarten's view that the disorder is trophic and developmental is probably the best at present." It usually starts in childhood, beginning as a rule in one of the bones of the face. "Of the cranial bones the anterior part of the frontal is usually most affected." (Bassoe).

The massive thickening of these bones leads to a gradual diminution in size of the cranial chamber and more or less obliteration of the foramina and accessory cavities of the skull. These changes eventually give rise to the various symptoms of cerebral compression and cranial nerve impingement. The orbit being more or less obliterated, exophthalmos is one of the results.

Diagnosis.—Though some authors consider *Osteitis deformans* of Paget as identical with this disease, still leontiasis ossea is described as a diffuse hypertrophy limited to the bones of the face and cranium while the osteitis deformans involves the spine and lower extremities as well as the cranium. von Bruns states that while osteitis deformans fibrosa may involve the skull alone it must be admitted that the skull affection may represent the beginning of a general disease of the skeleton. Osteitis deformans furthermore does not involve the bones of the face. *Acromegaly* always begins in the epiphyses of the long bones of the extremities. *Sarcoma* of the maxillary bones may be mistaken for the early hyperostosis of leontiasis ossea, or it may be associated with the latter.

Treatment.—There is no curative treatment of this malady, though operations have been performed with the idea of relieving pain due to nerve compression. The duration of the disease may vary from ten to thirty years.

[1] Arch. gén. de méd., October, 1902.
[2] New York Med. Jour., March 12, 1898.
[3] Jour. Nerv. and Ment. Dis.

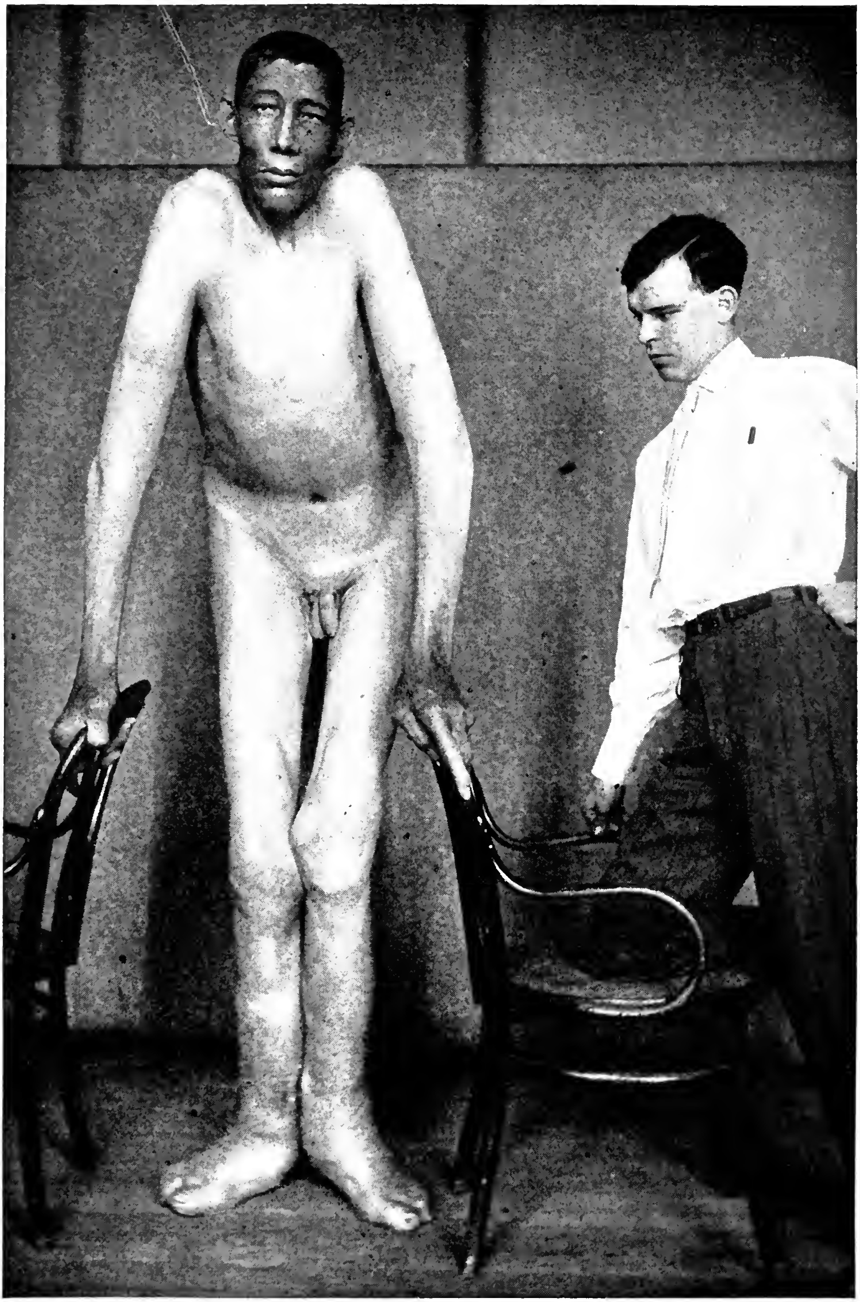


Fig. 84.—Case of pre-adolescent hyperpituitarism, with giant overgrowth. Enlarged sella turcica. Weight, 275 pounds; height, 8 feet, 3 inches. Note the narrow chest, enlarged joints, hypertrichosis, and large size of hands. (From Cushing's Pituitary Body.)

Osteitis Deformans.—Osteitis deformans, also known as *Paget's disease of bone,* is a very rare disease, leading to irregular but symmetrical enlargement and deformity of more or less of the bony skeleton. It occurs chiefly in middle life and is found most frequently in men. The cause of this condition is not known. While the long bones of the extremities become thickened and elongated they also become bent in various directions. These changes, combined with osteophytic deposits here and there and curvature of the spine, lead, at times, to very grotesque deformities, and a decided shortening of stature. The skull changes usually affect only the cranial bones in the form of an excentric hypertrophy. For this reason there are seldom present the symptoms of intracranial compression.

FIG. 85.—Osteitis deformans (Paget's disease) in a patient, aged seventy-two years. Duration, twelve years. Orthopædic Hospital. (Ashhurst.)

ACUTE INFECTIONS OF THE CRANIAL BONES.

Acute Pyogenic Osteomyelitis or Periostitis.—Acute pyogenic osteomyelitis or periostitis of the cranial bones is exceedingly rare as a hematogenous infection. While it may take place in this way after trauma, or even without the latter, it usually occurs in connection with an open scalp wound, or by direct extension from one of the accessory sinuses.

Acute infection under tension in the diploë, regardless of how it reached the area, gives rise to both the constitutional symptoms and the local signs of acute osteomyelitis, viz., usually a chill, always fever, and always marked pain and local sensitiveness. Infective thrombophlebitis may spread extensively through the diploëtic veins or the emissary vessels and reach one of the large venous sinuses, causing thrombosis, or the pus may rupture into the subpericranial area, stripping up the periosteum, or it may perforate the bone internally, leading to an extradural abscess with cerebral compression, or it may even lead to a meningitis, a local brain abscess, or a diffuse meningo-encephalitis, or it may serve as the focus of a pyemia. As in the long bones, so here in the skull, the early stages of the infection may be unaccompanied by marked swelling of the soft parts. Later, as the tension is relieved by perforation of the bone, there may be considerable swelling of the scalp. Necrosis may be limited or extensive. The peculiar thing about the cranial bone necrosis is that no involucrum is formed as in the long bones. Only occasionally is a slight one formed.

Diagnosis and Prognosis.—While the diagnosis is usually easy the prognosis is always serious because of the possibilities of intracranial infection.

Treatment.—The treatment indicated is drainage of the infected area within the first twenty-four or thirty-six hours. As in the case of the long bones, release of tension by removing one or more buttons of the outer table is all that is usually necessary. It is of the greatest practical importance in these cases to make early extensive incisions through the periosteum down to the bone because this causes the lymph stream to carry the infections away from the body. If there is any question about extradural infection the trephine opening should extent through the entire thickness of the skull. Later, when necrosis has occurred free drainage is still indicated until the necrotic bone is well outlined, when it should be removed, as waiting until it is loose would prolong the possibilities of intracranial inflammations.

Syphilis.—Syphilis of the cranial bones or their periosteal coverings is usually found as tertiary lesions of acquired syphilis, though it sometimes occurs as a hereditary manifestation in children. It usually starts in the pericranium, but may involve the diploë first. Both become involved more or less in either case. The brow and the top of the head are the favorite seats, the base being rarely affected. The spirochetes are abundant in the gummata of infants. Trauma is often the cause of the localization.

Symptoms.—The subjective symptoms may be few and mild. Though tenderness is present, pain is usually not a prominent feature unless the disease involves the dura, primarily, or secondarily as a pachymeningitis externa. When pain is present, as in some of the cases developing acutely, it is usually worse at night, as in most chronic bone inflammations.

The gummata appear as solitary or multiple lesions, tender, slightly elevated and firmly fixed to the bone. Chronic from the beginning, they tend to gradually increase in size and coalesce, often forming irregular serpiginous patches of bone destruction. The rarefaction and absorption of the bone, most marked along the Haversian canals, is accompanied by an overproduction and sclerosis of bone at the periphery of the lesion, forming at times tophi and nodules. The destruction, however, exceeds the new bone formation. The caseation and softening may extend to the dura, which usually acts as an effective barrier, or it may extend outward and lead to scalp ulceration and sinus formation with their characteristic earmarks. The dura may become thickened and contracted. The entire process may be limited

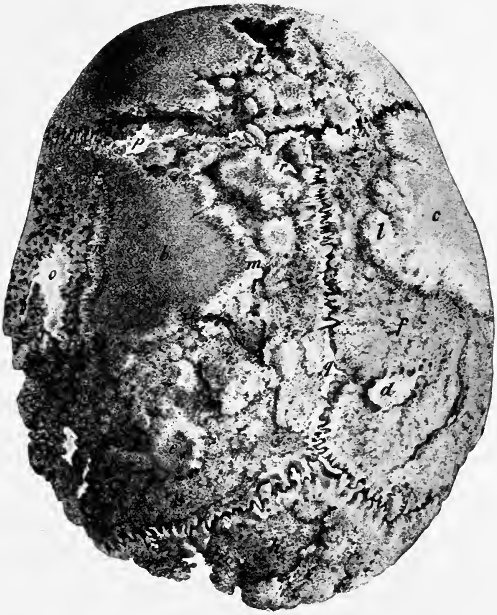


Fig. 86.—Syphilitic caries of cranium.

to a small area of local caries or it may result in extensive necrosis, usually in such form as to give the skull a worm-eaten appearance. Pulsation of the swelling may be present after perforation of both tables. The gravity of the case is usually altered by the mixed infection which often occurs in connection with the marked softening.

Diagnosis.—The diagnosis ordinarily should not be difficult. One or more chronic, slightly tender, rather painless swellings on the vault of the skull, with a history of syphilis some years before, and with a positive Wassermann reaction, would leave practically no question about the diagnosis. The vast majority of cases of *osteomyelitis* of the skull, especially on the forehead and the top of the head, not due to trauma, are syphilitic.

The diagnosis is most difficult in the early stages when there is no history of syphilis. In this case the solitary lesion might be mistaken for *sarcoma*, but the multiple lesions never. *Tuberculous osteomyelitis* might have to be differentiated. This, however, is usually found in children, and, in almost any event, has usually a primary focus of tuberculosis in the lungs or glands, or some other portion of the body. Not only that, but it is more apt to be found associated with a tuberculous sinusitis, especially of the mastoid. The tuberculin test should be positive. Other granulomata, though exceedingly rare, must be thought of.

In syphilis there can usually be found associated lesions, characteristic of the disease, in other parts of the body. Furthermore the positive Wassermann and the response to rigid antisyphilitic treatment clinches the diagnosis.

Treatment.—The treatment consists in energetic antiluetic treatment, which is often all that is necessary. Free drainage is indicated in all suppurating cases. Gummata resisting treatment should be opened, curetted and packed or excised. Dead bone should be removed with a chisel or curette, care being used to avoid unnecessary denudation of the living bone. Intracranial tension from extradural gummata or exudates calls for relief through trephining if there is no prompt response to medication. No delay is admissible if the pressure is great. In cases of pachymeningitis externa that have resisted treatment careful curettement is indicated, providing cerebral symptoms are present. Defects of soft parts or of the skull may be corrected through plastic surgery, though quite a number of cases are on record showing a considerable reproduction of the bone in these syphilitic cases, due probably to the activity of the dura.

Tuberculosis.—Tuberculosis of the cranial bones, while more common than it was formerly thought to be, is nevertheless a rather rare condition, limited almost exclusively to childhood. It is usually only a part of a more or less generalized tuberculosis. It occurs as circumscribed or diffuse lesions starting generally in the diploë. The circumscribed lesions usually perforate the bone in both directions, though occasionally only one or the other of the two tables may be involved. A cold abscess is the usual result. The diffuse lesions, the so-called infiltrating types, spread along the diploë, perforating here and there toward the dura or toward the scalp, resulting in more or less necrosis of the bone and tortuous sinuses in the soft parts. The granulomatous mass on the inner surface of the skull may push the dura away from the bone and set up a pachymeningitis. A leptomeningitis from direct invasion is rare, though not uncommon as a hematogenous infection. These tuberculous lesions tend to bone destruction exclusively, rather than to a combination of overproduction and absorption as occurs in syphilis. Tuberculosis of the temporal bone is in a class by itself, being usually secondary to tuberculosis of the mastoid. It will be described in a subsequent chapter.

Symptoms.—The symptoms of tuberculosis of the cranial bones are largely objective. Slight pain in the head and local tenderness followed by a soft, torpid, fluctuating swelling not due to trauma, with later discoloration and perforation of the overlying skin and sinus formation, constitute the usual sequence of symptoms. The afternoon temperature is always in evidence. The mouths of the sinuses have the characteristic appearance of tuberculous sinuses. At the bottom of the tract one can frequently find, in the circumscribed cases, a small circular sequestrum which can usually be easily lifted out, contrary to the case in syphilitic necrosis. The soft swelling may pulsate with the brain in some cases of perforation of the skull.

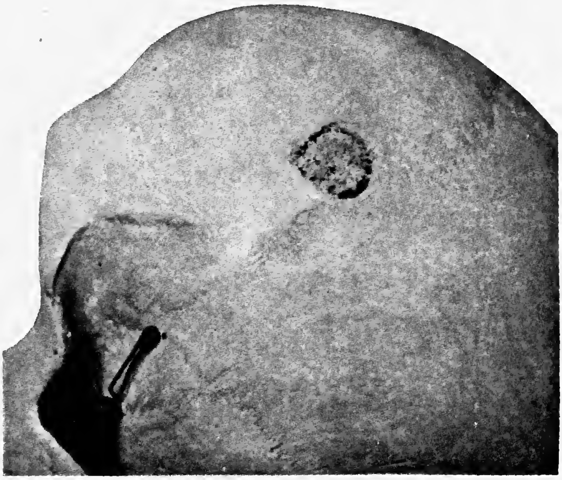


Fig. 87.—Perforating tuberculosis of the skull.

Diagnosis.—In the *differential diagnosis syphilis* can ordinarily be excluded by the absence of other lesions characteristic of syphilis, by the negative Wassermann test, and by the fact that syphilis of bone is usually found in adult life rather than during childhood. In the tuberculous cases one can usually obtain a positive tuberculin reaction. *Glanders* and *actinomycosis* are exceedingly rare in the cranial bones and, when they do occur, it is only as a secondary manifestation of the infection in some other part. The specific microörganism can be demonstrated in each case.

Treatment.—The treatment of tuberculosis of the skull consists in the operative removal of the local lesion if possible, unless contra-indicated by the gravity of the associated lesions. Operation is especially indicated where meningeal or cerebral symptoms indicate a pachymeningitis with pressure. Bone defects, as in syphilis, are sometimes filled in spontaneously. When operation is out of the question, the case must be handled as any other case of so-called surgical tuberculosis. The unruptured cold abscess should be aspirated and carefully injected with formalin and glycerine or iodoform emulsion; but if mixed infection has already occurred free drainage is indicated.

In any event the case always calls for the modern general dietetic and hygienic care of tuberculous individuals, including the use of the tuberculin.

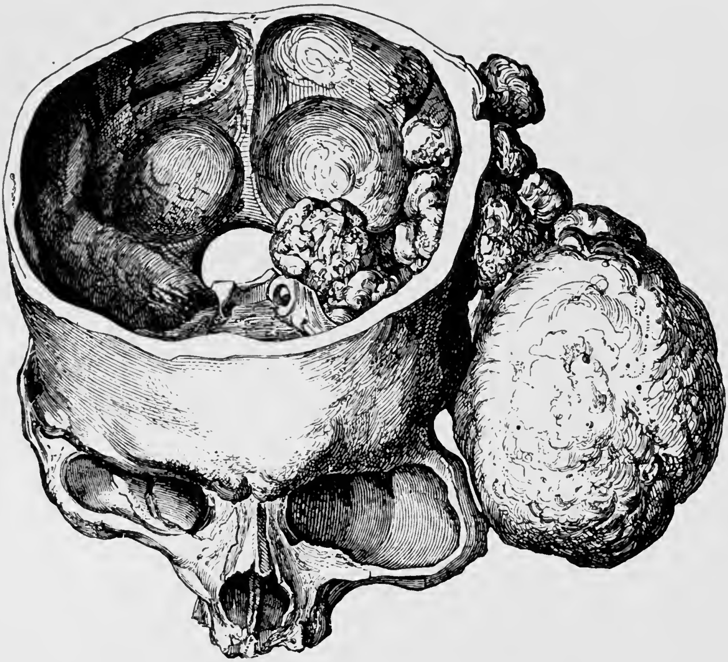


Fig. 88.—Exostosis of the skull.

TUMORS OF THE CRANIAL BONES.

Osteoma.—Osteoma is a benign tumor occurring as an *exostosis* chiefly on the outer surface of the cranial bones, though it is also found on the inner surface or in one of the accessory sinuses. It generally appears at puberty. *Enostosis*, arising from the diploë, is seldom, if ever, seen in the cranial bones. The exostoses are most frequently seen on the frontal or parietal bones, usually as a solitary growth and generally of the compact type. External and internal exostoses have been seen at the same site. As most of the cranial bones are laid down in membrane the fibrous osteoma is the prevailing type, though chondral osteoma has been met with in the ethmoid and sphenoid. Osteophytes, probably of inflammatory origin, are sometimes found on the inner surface of the cranial bones, especially in pregnant women and tuberculous cases.

According to their structure osteomata are spoken of as hard, eburnated or spongy. In size they vary greatly. While most of those on the cranium are sessile, the pedunculated are sometimes found.

Diagnosis.—The diagnosis of the *external osteomata* of the cranial vault is usually easy as they are slow-growing hard tumors firmly attached to the bone, with no invasion of the soft parts. They are entirely symptomless. Sarcoma, especially ossifying sarcoma and

FIG. 89.—Osteoma of skull.

FIG 90.—Same as Fig. 89, seen from below.

gumma, sometimes call for exclusion. König mentions local atrophy of the skull, with bulging due to intracranial pressure, as of some differential diagnostic importance.

The diagnosis of the *internal exostoses* is a more difficult matter. As they are of very slow growth the brain may show no signs of irritation or compression from a moderate-sized tumor, especially over a silent area. Where symptoms are present they are usually those of irritation or paralysis of the cerebral cortex or cranial nerves. Even then exostosis will hardly be thought of unless revealed by an x-ray examination, or unless an external osteoma is present.

The signs of *osteoma in the accessory sinuses* depend upon the special sinus involved. As it grows it causes an expansion of the sinus walls in the direction of least resistance with a displacement of the adjoining soft parts. There is also a tendency to sinus infection due to interference with drainage, and sometimes cerebral or meningeal infection, leading to the diagnosis of ordinary sinusitis. Thus a bulging over the region of the frontal sinus with displacement of the eye downward and outward, combined with attacks of sinusitis, is characteristic of a frontal sinus osteoma. In the sphenoidal sinus the optic nerves may be compressed or the growth may reach into the nasal cavity.

Treatment.—The treatment of exostoses depends upon the location and the form of the tumors, and the presence or absence of symptoms due to the growth. Thus a pedunculated or a very unsightly tumor should be removed; also one causing cerebral or cranial nerve symptoms or displacements of important structures, such as the eye. Those leading to sinus infection should also be removed. The internal and sinus cases will often call for exploration. If operation is attempted thorough removal should be the rule in order to avoid recurrence. The sinus cases naturally have a decided mortality rate due to infection.

Cavernoma.—Borchardt[1] cites an interesting case of cavernoma communicating with the superior longitudinal sinus, which presented itself as a pulsating tumor near the junction of the sagittal and lambdoidal sutures. The entire venous system of the skull was dilated, though the arteries were found to be normal at the subsequent postmortem. Intracranial pressure was evidenced by the bilateral choked disks. He regarded the case as a *progressive phlebectasia pericranii* of congenital origin.

Schöne has described 8 cases of central *cavernoma,* and Blecher 5 cases of *cholesteatoma* of the cranial bones. (v. Bruns.)

Echinococcus Cysts.—Echinococcus cysts of the cranial bones are exceedingly rare. They occur in the diploë, and those reported have been of the unilocular type, though most cases in the long bones are of the multilocular variety. Atrophy of the adjacent bone occurs. The complement-fixation test in the diagnosis of echinococcus lesions is very satisfactory.

Treatment.—The treatment of the unilocular cases consists in removal of the lining membrane and drainage.

Sarcoma.—Sarcoma of the cranial bones is rare in comparison with sarcoma of the extremities. It may be found at any site at any age. It is not infrequent in children, and has been found in the newborn. It may be primary or metastatic, and, though usually solitary, it may be multiple.

[1] Zentralbl. f. Chir., 1913, xxviii, 33.

Histology.—The histology of sarcoma of the cranial bones is the same as in other regions of the bony skeleton. It may start primarily in the pericranium, the dura or the diploë. Any one of the various cell types may predominate, the round, the spindle, or the giant cell, though the spindle cell seems to be most frequently found. The giant cell belongs to the myelogenous sarcoma. Often there are mixed-cell types. Endothelioma may arise from the vessels in the bone, giving rise to angiosarcoma.

Symptoms.—The symptoms naturally depend upon the location of the tumor, whether encroaching upon the cranial cavity or not, upon the matter of invasion of the brain or involvement of the cranial nerves or accessory sinuses, etc. As a matter of fact the dura seems to act as

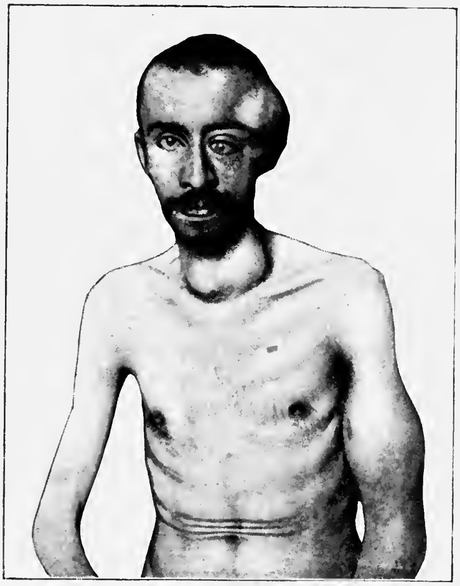


Fig. 91.—Osteosarcoma of the temporal region. Metastatic tumor in the arm and thyroid.

a barrier against invasion and so the sarcoma tends outward, no matter where it starts. In the cases starting on the inner surface the symptoms may be the general symptoms of brain tumor, plus, in many cases, the focal symptoms due to pressure on or invasion of some special point on the cortex of the brain. When perforation of the skull eventually occurs the cerebral pressure symptoms are relieved and the tumor becomes manifest under the scalp. Before long the scalp is invaded, its subcutaneous veins greatly enlarged and ulceration results in the usual bleeding fungus of sarcoma.

In *myelogenous sarcoma* arising in the diploë the periosteal irritation sometimes leads to the formation of a bony capsule on the outer side, resembling a separation of the tables, or, in the early stages, an osteoma.

In this variety and in those starting on the surface of the skull there are usually no brain symptoms, except possibly headache, and the tumor presents itself early as an external swelling with sometimes more or less pain and tenderness.

Diagnosis.—The diagnosis of sarcoma of the cranial bones, like most deep tumors in other portions of the body, is seldom made in the earliest stages when operation has the most to offer. Too often it is the visible or palpable tumor that is the first recognized sign of sarcoma of the

Fig. 92.—Fungating osteosarcoma of cranium.

skull. At first this tumor is a flat, rounded swelling attached immovably to the bone. Though it may be hard at first, it frequently becomes softer in the later stages, and, as it grows more rapidly in the softer tissues than in the bone, it may be somewhat constricted at the base. The galea for a time may act as a barrier to malignant invasion, but soon the fixation of the skin, with its enlarged veins, becomes marked.

Given such a tumor in the early stages, it is necessary to *differentiate sarcoma, primary* or *secondary, secondary carcinoma, gumma, tuberculosis* and *actinomycosis.* The rare *myeloma, chloroma* and *echinococcus cysts*, as well as the more common *simple osteoma*, must also be considered.

A general physical examination will help to determine the presence or absence of similar or coincident lesions in other portions of the body, and thus aid in the differentiation of syphilis and tuberculosis, metastatic sarcoma and secondary carcinoma. An accurate, orderly clinical history, combined with the usual Wassermann and tuberculin tests, are absolutely necessary. A skiagraph may be of distinct service. In case syphilis cannot be excluded by these means a vigorous antisyphilitic treatment for three weeks should be tried. Tuberculosis is more apt to present itself as a soft fluctuating mass, a cold abscess from the beginning; while actinomycosis is a distinctly inflammatory tumor, and is practically always present in some other part of the body primarily. After the tumor is once open the finding of the ray fungus settles the diagnosis. Myeloma shows itself as multiple myelogenous tumors, confined entirely to the bony skeleton, with the Bence-Jones body in the urine. Myelogenous sarcoma in the early stages with its outer wall of new periosteal bone, and ossifying sarcoma, may be mistaken for a time for simple osteoma (exostosis). The rapid growth of sarcoma, however, soon rules out osteoma. Sarcoma of the dura must present symptoms more like a brain tumor, and hence is not usually considered in the above diagnosis until it begins to perforate the skull, or until a skiagraph offers the suggestion.

Treatment.—The treatment of sarcoma, here as elsewhere, consists in wide excision unless the case is considered inoperable because of metastasis or too extensive local invasion. Excision with the actual cautery has distinct advantages. From the standpoint of the cell type the myelogenous variety should offer the best prognosis, but, as a matter of fact, the external or pericranial tumor can be recognized earliest of all, and hence should offer a prognosis which is less serious than that of the deeper sarcomas. They are all bad.

Myeloma (Multiple Myelema).—Myeloma is a systemic disease characterized by the formation of multiple tumors confined entirely to the osseous system, the bones of the trunk and skull rather than the long bones being chiefly involved. Starting in the marrow it leads to a softening and absorption of the bone. Simultaneous development of multiple foci, rather than metastasis, is the rule. It has been found more often in males over forty years of age. The cause of the disease is unknown. The urine in these cases contains a heterogenous albumose known as the Bence-Jones body. This body has been found in the urine prior to the recognition of the tumors. The prognosis is absolutely hopeless.

Chloroma.—Chloroma is a very rare form of tumor which derives its name from its green color. It seems to have some connection with myelogenous leukemia and spreads by metastasis like a sarcoma. Simmonds and Römer[1] conclude that "Chloroma is only a biological

[1] Deutsch. med. Wchnschr., 1914, xl, 260.

subvariety of leukemia with a special tendency to malignant proliferation." Reid[1] states that "they originate in the periosteum, generally of the skull bones, and show unbounded proliferation into the soft parts. They are generally accompanied by changes in the blood picture." He cites a case, however, which did not originate in the periosteum and which was not accompanied by blood changes. The blood changes are those of myeloblastic leukemia. Dock[2] calls attention to the fact that, notwithstanding their usual origin in the periosteum, they show none of the elements ordinarily found in periosteal tumors—no spindle or giant cells, and no tendency to bone formation. They are associated with the myeloblastic type of leukocyte. He calls it an aberrant form of myelomatosis. Authors disagree as to whether the disease is to be classed among the leukemias or the sarcomata. The cause of this disease is unknown. It occurs chiefly in the bones of the skull, the spine and in the humerus. The tumors on the skull are said to form "flat, plate-like masses, often extending over large areas." (Hektoen-Riesmann.[3])

[1] Beitr. z. klin. Chir., 1915, xcv, 47.
[2] Am. Jour. Med. Sc., 1893, cvi, 152.
[3] An American Text-book of Pathology, p. 205.

DIAGNOSIS AND TREATMENT OF TUMORS, INFLAMMATIONS AND ABSCESSES OF THE BRAIN.

By ALLEN B. KANAVEL, M.D.,

TUMORS AND ALLIED PROCESSES IN THE BRAIN.

Diagnosis in Brain Tumors.

There is no more fascinating field in surgery than that of diagnosis in brain tumors—fascinating because it calls for the highest degree of reasoning power based upon an intimate knowledge of intricate anatomical structures and for an intensive study of the symptoms and signs to be elicited in a given case. Many are the disappointments of the most careful observer and yet, on the other hand, brilliant success does at times reward the student. Much of the pessimism of the profession regarding results in brain tumor cases is justified, but unfortunately this pessimism has been unduly magnified by careless diagnosis on the part of the internist and by hasty, injudicious operations on the part of the surgeon. These cases should all be under the care of the trained observer for many days before any operation is carried out, except under the most urgent circumstances. The operations should be performed with the knowledge that more than familiarity with surgical cleanliness and technic is required by the surgeon. Each operation should be planned with the idea of reaching and removing the tumor, not with the idea of opening the skull, and, after a hasty examination, doing a decompression. Manifestly this calls for the possession of a high degree of neurologic knowledge by the surgeon as well as the internist.

That care should be exercised by the diagnostician is especially emphasized when one remembers that while there are known focal centers, there is a large "silent" area in the brain. Association fibers serve to confuse the picture by reacting to neighborhood stimuli and by assuming destroyed functions if the process grows slowly. The most important factor is that the known tracts and focal centers are so closely associated that involvement of one will produce spurious signs on the part of the others. Therefore, it follows that the history of the development of the tumor is of the greatest importance. The very earliest symptoms should be painstakingly sought for, since in the later stages the pictures become almost too complex for understanding; for example, the early deafness may serve to differentiate a cerebellopontine from a cerebellar tumor. In general we should always bear in mind that the symptoms fall into four groups:

A. Those produced by irritation or depression of the neurological or physiological function of the area involved; *e. g.*, monoplegic motor paralysis, or acromegaly associated with hypophyseal disease.

B. Those produced by irritation or depression of neurological or physiological function in adjacent nervous structures and changes in other adjacent anatomical structures; *e. g.*, sensory aura in motor tumors, adiposity in third ventricle hydrops, changes in the cerebrospinal fluid, and the enlarged sella turcica in hypophyseal tumors.

C. Those associated with the nature of the growth. Here we emphasize the coincident systemic tuberculosis in the tubercles of the brain; the leukocytosis, fever, ear and nose findings, etc., associated with abscess; the Wassermann and syphilitic findings in gumma; the destruction of tissue and rapid growth associated with sarcoma; the cystic degeneration and sudden hemorrhage with consequent signs found in gliomata; evidences of carcinoma, deciduoma malignum, neurofibromatosis, etc.

D. Those produced by the general increase of intracranial pressure.

To elicit these facts a most careful examination is necessary, and the neurological student will do well to familiarize himself with a definite routine in his investigation. The following method is suggested. It must be amplified when the general location of the tumor has been found, and intensive study must be directed to this location.

I. History given by the patient of the mode of onset and course of the disease. After the statement is made by the patient, it must be amplified by direct questioning bearing on the points brought out by the patient and suggesting new correlative data for the patient to accept or refuse as a part of his history. Questions should be asked concerning sensory and motor symptoms; *e. g.*, spasms, convulsions, anesthesia, burnings, and tinglings. The date of the onset of each new symptom is of the greatest importance.

II. Family history, *e. g.*, syphilis, tuberculosis.

III. Previous disease, and if a woman, obstetrical history; *e. g.*, syphilis, nephritis, ear disease, nasal disease, injuries, infected miscarriages.

IV. Examination.

A. General physical examination.

B. Examination of the nervous system.

1. Mental functions, *e. g.*, intelligence, memory, drowsiness, coma, hallucinations.
2. Local examination of head, *e. g.*, local tenderness, tumors, thin hair, local infection.
3. Cranial nerves. Examine each in order for irritation and paralysis. Gross tests are made of the second and eighth and these reserved for full study later.

(*a*) Smell.

(*b*) Field of vision, form, color. Ophthalmoscopic examination, choked disk, atrophy, hemorrhages, choroiditis, etc.

(*c*) (*d*) (*e*) Ocular movements, convergences, diplopia, nystagmus. Pupils—comparative size, shape, reaction to light, accommodation.

(*f*) Sensation—face and mouth.

(*g*) Motor: face, forehead, taste, chorda tympani in anterior two-thirds of tongue. Mouth: masseters, temporals.

(*h*) Hearing—air and bone.

(*i*) Taste—posterior third of tongue, anesthesia of pharynx, difficulty of swallowing.

(*j*) Palate. Heart. Respiration. Vocal cords.

(*k*) Motor—sternomastoid and trapezius.

(*l*) Motor—tongue.

4. Spinal nerves.

(*a*) Motor—head, neck, arms, intercostal and abdominal muscles, legs. Investigate paralysis, paresis, incoördination in gait, and adiadokokinesia and pointing tests, atrophy.

(*b*) Sensory—subjective: pain, headache, vertigo, tingling, formication. Objective: absent and increased reaction, touch, pain, temperature, stereognosis.

5. Reflexes.

Superficial: conjunctival, palatal, epigastric, abdominal, cremasteric, plantar, anal. Deep: jaw, radial, knee, Achilles tendon, ankle-clonus, knee-clonus, Babinski.

6. Sympathetic: proptosis, exophthalmos, local or general vasodilatation or contraction.

7. Functional tests and examination: speech, bladder, rectum, genital, hypophyseal adiposity, growth, etc., pineal.

8. Special laboratory tests: blood, urine, Wassermann spinal fluid, Abderhalden, x-rays, brain puncture.

Cerebral Localization.—General.—The hope of relief in an individual case must rest upon our knowledge of functional localization. The difficulties of accurate localization rest, not so much upon our ignorance of the centers for special function, as upon the fact that the brain is largely made up of association centers and tracts, so that although we may know well the center for a special function, we may yet be in doubt in a given case as to whether there may be involvement of the center itself, of the fibers leading to it, or away from it, whether there may be involvement of the association fibers correlating the function, or of the motor fibers expressing the function. This is well illustrated in cases of aphasia of which there are so many forms.

Galen drew attention to the occurrence of contralateral paralysis in traumatic lesions of the head, and the small trephine openings over the motor areas in the Peruvian skulls suggest a like knowledge by these people. Gall, the founder of phrenology, must be given credit for the revival of modern study upon this subject, since he recognized more clearly than his predecessors that the cerebral hemispheres were the seat of intelligent acts and functions, although Flourens disproved the assumption Gall made as to their seat. Broca in 1861 confirmed the older statements of Dax that aphasia in right-handed people was associated with a lesion of the third frontal convolution of the left side, hence known as Broca's convolution, although later Marie proved the lack of constancy of this. Hughlings Jackson, in 1864, drew attention to localized spasms with lesions of certain parts of the central convolutions. The first direct evidence of motor localization was brought forward by Fritsch and Hitzig in 1870, when by experiments on dogs they showed that the gray matter of the cortex was excitable and that by irritation at specific points it was possible to produce certain movements. Ferrier elaborated and confirmed these observations on the monkey. Horsley later added much, while Schafer, Beevor, Cushing, Frazier, and many others have contributed both experimental and clinical observations. To Sherrington particularly, we owe a great debt for his careful and painstaking studies, especially that part in which he demonstrated that the motor zone lies in the anterior central convolutions.

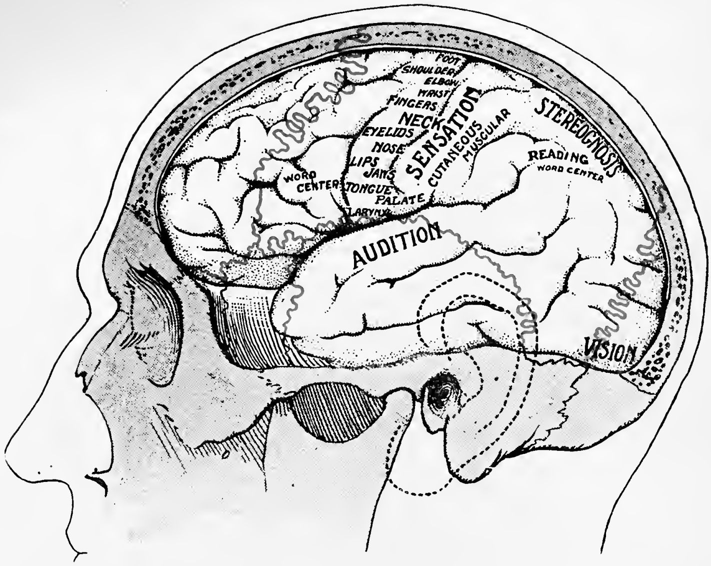
The relations of the various convolutions and sulci should be clearly understood by the neurological surgeon, since at any time it may be necessary for him to enter various areas for exploration or the extirpation of tumors. The sulci are most vascular and should be avoided where possible. The most superficial layer of the brain is made up largely of association fibers; consequently destruction of this layer may not lead to permanent impairment of function. A microscopic section will show the following cell structure from the cortex inward, the following layers with approximate thicknesses as follows: (1) molecular, 0.34 mm.; (2) small pyramidal, 0.90 mm.; (3) stellate cells or granular layer, 0.22 mm.; (4) large pyramidal—in the motor area has large solitary cells, cells of Betz, 0.22 mm.; (5) polymorphous cell layer, 0.31 mm.

Roughly, the function of these layers may be classed as follows: the pyramidal cells, associative; the granular layer, sensory; the large pyramidal cells of Betz, motor; and the polymorphous layer, which presides over the lower functions such as sexual desire, the getting of food, etc. From the cortex the various fibers pass to the base of the brain and to different parts making groups known as projection, association, and commissural fibers, a complete discussion of which would be too extensive for inclusion here.

Attention should be drawn to the centers for the cranial nerves, since involvement of these is of so much importance in localization. The centers and function of the first eight are well known. When the

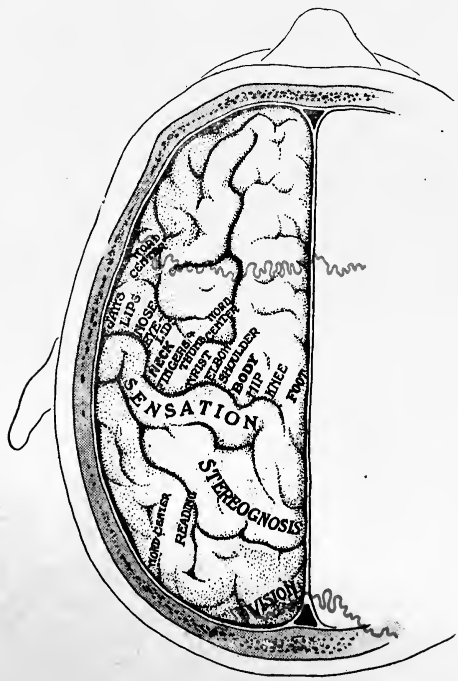
PLATE II

FIG. I



Cerebral Localization.

FIG. 2



Cerebral Localization.

Note the large number of centers upon the vertex.

centers for the others are involved by a tumor lying along the aqueduct of Sylvius and the fourth ventricle, certain reflex acts are impaired, such as respiratory and vasomotor function, cardiac inhibition, mastication, deglutition, sucking, vomiting, phonation, articulation, in addition to the impairment of the function of other cranial nerves. In such cases we speak of these acts as if they had a special center, *e. g.*, cardiac center, swallowing center, vasomotor center, etc., rather than distinguishing the individual nerve, since the impaired function can seldom be referred to one nerve or separated from others.

The "silent area" found in the human brain is largely made up of association fibers. These "silent areas" increase in amount as we ascend the scale of intelligence. They are particularly seen in the locations of known sensory tracts and should be described in connection with the tract with which they are most closely connected; *e. g.*, the visual-sensory and visual-association, the auditory-sensory and the auditory-psychical. This also serves to emphasize the difficulty of localization since the higher we go in the scale of life the greater must be the latitude allowed for the location of a tumor because here it may either involve the center or its association tract. Thus we see that in the future the knowledge of localization must come from intensive study of the physical findings and the chronological history of disease in each individual case, the collection of numbers of such observations, and the correlation of the findings, rather than from experimental observations on lower animals.

The most satisfactory results of localization study have been secured in investigations of the motor area. While it was originally believed that the motor areas extended both anteriorly and posteriorly from the central fissure, we know now, thanks to the investigations of Sherrington, that they are located anterior to the fissure. The relation of these centers may be seen by reference to the accompanying drawing (Plate II), showing the centers as depicted by Sherrington and others. The motor cells extend to the floor of the central fissure.

In operating it should be remembered that these centers lie more on the vertex than on the side of the brain. In dogs the ablation of these centers produces a paralysis from which the dog later recovers; in monkeys, the recovery is slower and less complete; while in man a destruction of the centers produces permanent paralysis. At times, however, we see recoveries from a paralysis apparently complete, but such cases are probably due to an injury of the association tracts. At times such a paralysis may be seen clearly to be outside of the motor centers, since the loss of motion is chiefly in relation to volitional movements, *e. g.*, the arm may be paralyzed yet may be raised in association with a movement involving the other arm. In such cases a small degree of recovery may be noted.

The predominant influence of the motor cortex is inhibitory of the stronger muscles of the body and the tonus which is constantly maintained. Thus when we excite the motor cortex, an inhibition of the postural tone and of the antagonistic muscles is brought about as well as a stimulation of the muscles directly involved. This is proved by the experimental removal of the cerebrum in dogs, which leads to general muscular rigidity, "decerebrate rigidity" so-called. It follows, therefore, that in those cases in which the inhibitory function of the cerebrum is removed, as for instance where conduction through the pyramidal tracts is interfered with, we will have spasticity of the muscles.

Sherrington and Grünbaum have shown by experimental observation that tactile and muscular sensibility is chiefly related to the central convolutions including those anterior to the central fissure, but that they are especially dependent upon the postcentral gyrus. Starling,

Fig. 93.—Endothelioma of forebrain. (Northwestern University Medical School collection.)

to whom I am indebted for abstracts freely taken, says that Fleshsig has shown that fibers from the thalamus which may probably be regarded as continuations of the fillet system, are also distributed to other portions of the cortex, *i. e.*, temporal, frontal, and occipital lobes. It is therefore not surprising that the hemi-anesthesias produced by lesions of the central convolutions are rarely or never complete.

The senses of pain and temperature probably lie in the intermediate postcentral zone of Campbell, *i. e.*, in the posterior part of the postcentral gyrus, and stereognostic sense in the parietal lobe.

Special.—Frontal Lobes.—The third left frontal lobe—Broca's convolution—has long been considered as the center for motor speech and undoubtedly we do at times find an impairment of speech from tumors located here; but whether this impairment is due to destruction of the tissue at that area or to pressure upon adjacent brain-tissue, is open to question. At the present time, for the reasons mentioned below, when discussing temporal lobe tumors, considerable doubt must be thrown upon this assumption.

The presence of psychical disorders has also been ascribed to tumors of the frontal lobes, but it must be admitted that these phenomena may be associated with tumors in any part of the brain, as Müller has shown, and probably they have little localizing value. Franz has shown by experiments on monkeys that destruction of the frontal lobes causes loss of recently formed habits. He concludes that the frontal lobes are the means by which we are able to learn and form habits, that is, to regulate our behavior in accordance with the needs of our position in society.

Fig. 94.—Tuberculomata of cortex—monoplegic signs in the early stages. (Northwestern University Medical School collection.)

Bruns first drew attention to rigidity of the neck and cerebellar ataxia and thought these symptoms were due to tumors lying in the marginal gyrus and the corresponding portion of both frontal lobes. Granger and Stewart have drawn attention to the disappearance of the abdominal and epigastric reflex on the opposite side and a fine tremor on the same side which they have shown in some cases by holding the extremities outstretched. This finding is not constant, however, and when present is most often seen in the arm. *Petit mal* may be seen. Early and persistent anosmia due to pressure on the olfactory nerve may be seen in tumors beginning on the under surface.

Motor and Sensory Zones.—Tumors of the cortical motor zone lying for the most part in the anterior central gyrus give contralateral signs, those upon or near the surface being characterized by irritative symptoms; *e.g.*, epilepsy followed by paralysis, the latter being primarily monoplegic —brachial, facial—and later more general (Fig. 94). The deeper the tumor lies, the less irritative it becomes and the more a paralysis may precede convulsions. Moreover, the extent of paralysis is great early in its course extending even to a complete hemiplegia at the internal capsule or above (Fig. 95). Hemorrhage into a tumor, for instance into a glioma, may produce a sudden paralysis. Paracentral lobule tumors may give bilateral symptoms.

Owing to the juxtaposition of the sensory areas in the posterior central gyri, the convulsive attacks are frequently preceded by aura, such as paresthesia in a part of an extremity—burning in the distribution of a nerve of the foot. As the growth extends into these

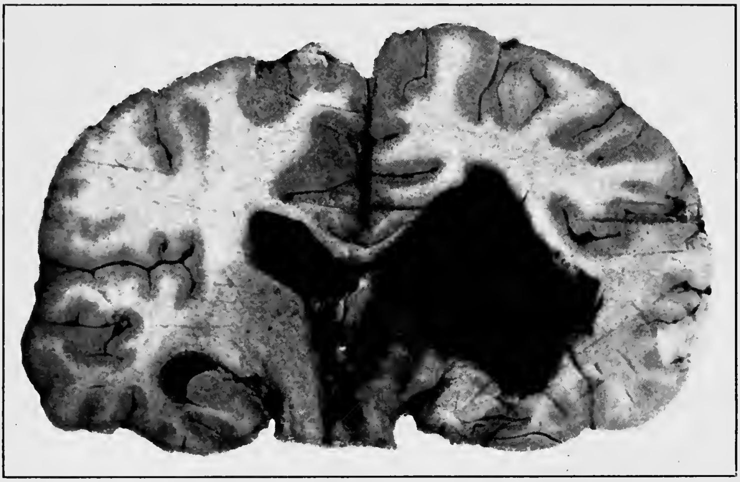


Fig. 95.—Central glioma—early hemiplegia.

areas the evidences become more marked although complete hemianesthesia is seldom produced. There may be impairment of tactile sensibility alone, or all types of cutaneous sensibility may be affected. The sense of position may be affected. Complete and persistent analgesia and thermo-anesthesia are apparently never caused by circumscribed cortical foci.

Astereognosis, *i. e.*, the loss of ability to recognize objects by palpation, may be seen, especially in tumors of the postcentral gyrus. The deeper the tumor lies, the more extensive the anesthesia, although it is seldom characteristically hemilateral unless the lesion involves the posterior zone of the internal capsule or the corresponding ganglion masses in the optic thalamus, or the complete bundles in their course. Symptoms of sensory irritation, *e. g.*, contralateral pain, are uncommon in cortical lesions but may accompany deeper foci.

Temporal Lobes.—The centers definitely established for the temporal lobes are the bilateral ones for taste and smell and the left unilateral center in right-handed individuals for sensory appreciation of speech. However, owing to the pressure of tumors upon adjacent areas, the symptoms in these cases may be most complex. Tumors involving the median area of the temporal lobes, the gyrus fornicatus, and the uncus, give rise to the so-called uncinate fits, an attack beginning with a disturbance of taste or smell, generally most unpleasant, followed by a dreamy, confused state or semi-unconsciousness lasting several seconds. These attacks may be accompanied by motor phenomena, such as smacking of the lips or even convulsions.

It should be remembered that direct pressure upon the first nerve may produce similar sensations. The exact location and limitations of the centers for taste and smell are still undetermined. In animals, with these senses highly developed, marked growth is seen in the olfactory lobe including the bulb, the dentate convolution with the hippocampal gyrus, the part of the gyrus fornicatus encircling the corpus callosum and the anterior commissure. To these areas the sense of taste and smell are generally ascribed but nothing definite is known.

Owing to the complexity of the function of speech, the exact location of the centers controlling it is somewhat doubtful. It is thought that sensory aphasia, word deafness, loss of the power of understanding speech, may be produced by a lesion of the posterior part of the first left temporal convolution or in the angular or supramarginal gyri; while pure alexia, word blindness, occurs with destruction of the posterior part of the third left temporal convolution.

It must be remembered that these are not centers in the strict interpretation of the word, but are really association tracts, and that interruption at various points will give varying types of aphasia. Broca's convolution in the frontal lobe has long been considered as the motor center, but reports of clinical cases of tumors in this region without impairment of speech—a condition which has been especially studied by Marie—combined with the experimental evidences that this center can be destroyed without harm, and with microscopic proof that the cells do not resemble those of known motor areas, all cast doubt upon this assumption. It should not be forgotten, however, that tumors in this region have produced loss of speech; whether due to local destruction or pressure upon adjacent areas may be open to question. It is thought by some that pure motor aphasia is to be associated with a lesion of the lenticular nucleus or its neighborhood, in the anterior part of the genu of the internal capsule and possibly of the external capsule.

It should be noted that temporal lobe tumors may cause convulsions or disturbance of consciousness which are ushered in by auditory aura, such as tingling and whistling in the opposite ear. If the tumors lie deeply, pressure upon the posterior end of the internal capsule may produce contralateral hemianesthesia or even hemiplegia; likewise hemianopsia may appear in the contralateral half of both visual fields due to involvement of the underlying optic radiation. Pressure upon the optic thalamus, since it is a reflex center for emotional expression, may produce marked diminution of emotional expression upon the opposite side of the face.

Occipital Lobe.—Since the occipital lobe is the center of vision, the characteristic evidence of tumor here is disturbance of the visual sense (Plate III). The center is situated on the mesial aspect for the most part, lying partly above and partly below the calcarine fissure. The lower quadrant of the half field is represented above the fissure, *i. e.*, in the cuneate lobule; the upper quadrant below, *i. e.*, in the lingual lobule. It follows that in rare cases, temporonasal hemianopsia may be seen and in extremely rare cases, quadrate blindness. Evidences of irritation may be seen in hallucinations of vision such as flashes of light. These frequently precede hemianopsia, but may be met in the blind area later. Bruns says choked disk is rare. Wernike's hemiopic pupillary phenomenon of course is absent.

"Wernike's hemiopic pupillary phenomenon is an absence of pupillary contraction when a ray of light is thrown on the blind half of the retina of an eye having hemianopsia. It signifies a lesion of the visual path behind the chiasma and below or at the corpora quadrigemina. In retroquadrigeminal hemianopsia, where the lesion is anywhere between the corpora quadrigemina and the visual cortex, the pupillary reaction is normal." (Stewart.)

Central Gray Matter.—Tumors lying in the central gray matter and basal ganglia and in the wall of the third ventricle, produce the general symptoms of brain tumor with varying phenomena as the different centers may be involved. The picture is often most complex. Weisenberg has collected the literature and classified tumors of the third ventricle as follows:

"1. Those cases in which a tumor of moderate size is situated in the floor of the third ventricle and in which there is no extension into the foramen of Monro or aqueduct of Sylvius.

"2. Small tumors so situated as to obstruct the foramen of Monro, the position of which can be changed by deviation of the head.

"3. Those tumors, whether large or small, which either extend into the aqueduct of Sylvius affecting the surrounding structures by direct extension or pressure, or those in which the posterior portions of the cerebral peduncles and pons are compressed, either by direct pressure or by dilatation of the aqueduct of Sylvius.

"The first class does not offer specific symptoms, but present evidences of internal hydrocephalus, viz., headache, choked disk, nausea, vomiting, and dizziness. In tumors of large size, indirect pressure upon the internal capsule causes paresis of the corresponding limbs. These symptoms may likewise result from internal hydrocephalus alone. The reflexes are nearly always increased. The mental symptoms, generally supposed to be present in tumors of the third ventricle, are attributed by Mott to impairment of the function of the cortex as a result of the pressure of the dilated ventricles.

"The second class is unimportant as but one case has been observed. This group presents a variation in symptoms of headache, nausea and impairment of vision upon tilting the head forward.

"The third class offers a fairly well-recognizable symptom-complex. The symptoms arise from involvement of the third nerve nuclei, red nucleus, or superior cerebellar peduncles and from pressure upon, or destruction of, the posterior longitudinal bundle or the intercommunicating fibers between the third nuclei. Among the symptoms noted are disturbance of associated ocular movements, oculomotor palsies, large pupils with impaired reaction, protrusion of the eyeballs, cerebellar ataxia, symptoms arising from pressure upon the pineal gland, and the general symptoms of tumor cerebri."

In central tumors the internal capsule is generally affected with consequent hemiplegia. In Oppenheim's experience, the facial is frequently first involved, accompanied by impairment of the reflexes as in pyramidal involvement. There may be motor excitability, contralateral hemichorea, or athetosis, increased on voluntary motion; hemianesthesia; hemianopsia. Many thalamic tumors may have no symptoms while in other cases contralateral movements as above, due to adjacent rubrospinal tract involvement, may be seen accompanied at times by contralateral subjective sensations of heat, cold, pain, etc.

Corpus Callosum.—There are no definite signs of lesion in the corpus callosum. Bristow has given the following symptom-complex as suggestive: slight signs of general pressure with marked impairment of intelligence, hebetude, hemiparetic symptoms followed by involvement of the opposite side and absence of involvement of cranial nerves. Large incisions may be made through the corpus callosum without serious permanent symptoms.

Cerebellum.—The complex functions of the cerebellum have been a fruitful source of study. The symptoms of tumor growth are better understood if we remember that complete unilateral extirpation in animals gives rise to three symptoms; slight loss of power upon the same side of the body, asthenia; considerable loss of tone on the same side, atonia; tremors or rhythmical movements of muscles on the same side accompanying any willed movement, astasia. An animal so affected lies upon the same side, being unable to stand, the head and neck are curved to the side on which it lies, and upon attempting to stand, the animal falls to the same side. After a time although it may stand, it has the symptoms mentioned above. Sherrington concludes from such investigations that the cerebellum is the head ganglion of the proprioceptive system acting as a center to which are sent the afferent impulses from the cord, fifth nerve, and especially the labyrinth. "It furnishes the subconscious basis for the guidance of the motor functions of the cerebrum. Through its connections with the bulb it augments the tonic activity of the muscles and consequently when the cerebrum is removed, gives rise to rigidity of the body known as 'decerebrate rigidity.'" (Sherrington.)

The symptoms of tumors as emphasized by Stewart, Oppenheim, Hoppe, and others, may be summarized as follows: Stewart and Holmes have described a typical picture of lateral lobe tumors in which symptoms appear upon the ipsolateral side consisting of paresis, diminished muscular tone, asynergia on voluntary movements, especially in the arm, weakness of conjugate movements of the eye toward lesion, horizontal nystagmus on the ipsolateral side, and subjective vertigo in which objects appear to rotate toward the contralateral side. Adiadokokinesia and insecurity in standing on the ipsolateral side are therefore important signs. Oppenheim, Spillar, Hoppe, and others have found these symptoms at times, but again they may be absent.

Vertigo with loss of equilibrium and nystagmus without a preponderance of ataxia on either side are seen especially in vermis tumors. Cerebellar "fits" have been seen in a few cases. These are characterized by tonic spasms, sudden in onset, especially in the face on ipsolateral side. The ipsolateral leg is adducted, the contralateral abducted and there is a screwlike rotation of the limbs, trunk, and head about their own long axis.

Cerebellar tumors may be latent or atypical. The symptoms also vary with the location of the tumor. The extracerebellar tumors naturally give rise to extracerebellar symptoms early, and intracerebellar, late; *e. g.*, pressure or irritation of fifth, seventh, eighth, and other cranial nerves, pressure on pons, with alternating hemiplegia and paralysis with conjugate deviation toward the side of the tumor, pressure upon the medulla with its centers and nerves, pressure upon the pyramidal tracts, with hemiparesis and paraparesis spastic in nature, pressure obstructing the flow of the cerebrospinal fluid with hydrocephalus with pressure upon the optic nerve and blindness, also anosmia, occipital lobe symptoms, and increased intraspinal pressure possibly destroying knee-jerks. The general symptoms are prominent; vomiting is quite constant, bilateral choked disk appears early, headache is most often in the occipital region accompanied by pain in the neck and the upper part of the back, but it may be in the frontal region.

Cerebellopontine Angle.—Tumors here if typical in onset are easily recognized. In this region as elsewhere, a study of the symptoms in their chronologic order is of the greatest importance. Since the tumor is frequently a neurofibroma or endothelioma growing from the eighth nerve, the patient gives a history of a slowly developing buzzing or ringing in the affected ear followed by deafness. The coincident or subsequent involvement of the fifth, sixth and seventh nerves gives symptoms ordinarily ushered in by burning or tingling over the face on the same side and loss of corneal reflex. This is accompanied or followed by evidences of pressure upon the cerebellum, pons, and medulla; vertigo, ataxia, nystagmus, paralysis of conjugate deviation, and bulbar symptoms. General symptoms of brain pressure develop early. The absence of these and a tendency to bilateral involvement tend to differentiate the tumors of the pons from the tumors of the cerebellopontine angles, while in cerebellar growths the cerebellar symptoms precede the nerve symptoms and are more marked. A somewhat similar picture may be produced by basilar syphilis or meningitis, by sarcomata growing from the meninges, gliomata growing from the ventral surface of the cerebellum, as well as by other tumors of the immediate neighborhood.

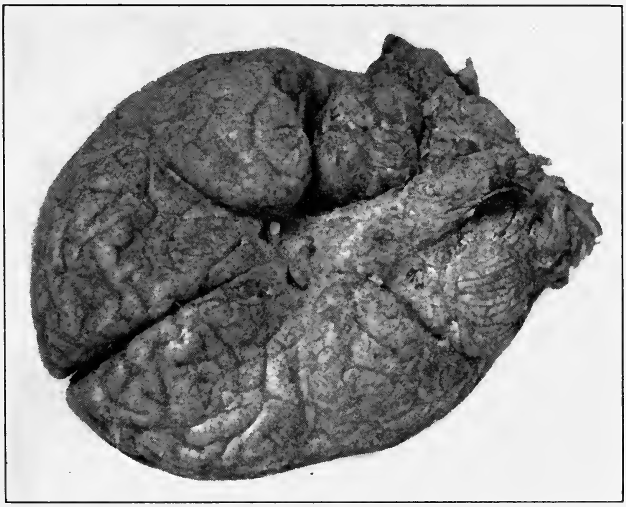


Fig. 96.—Cerebellopontine tumor. This patient presented but few of the typical symptoms of cerebellopontine angle tumors, having no definite paralysis of the seventh or other cranial nerve symptoms. The slight weakness in the left arm and leg with a history of some slight impairment of auditory function combined with the evidences of general brain pressure led us to do suboccipital operation. The tumor was found and a considerable area scraped away but owing to cardiac symptoms appearing due probably to pressure on the vagus whenever the tumor was touched in its deeper part, the operation was discontinued. The patient recovered from the immediate operation but died six weeks later of brain pressure. (Wesley Memorial Hospital, No. 56035.)

Pons and Medulla Oblongata.—The tumors of the pons are most often gliomata or tuberculomata, and the local signs are more marked than the general. Choked disk is generally absent. The typical picture is that of a *hemiplegia alternans,* presenting commonly a paralysis of the fifth, sixth and seventh nerves, on the ipsolateral, and the extremities on the contralateral side. The eighth nerve may be involved on one or both sides, and the third on the same side. The seventh may be the only nerve involved early, and Oppenheim has reported several cases in which long before paralysis of the opposite leg, the patient presented ipsolateral facial paralysis, paralysis of conjugate deviation, and Babinski's reflex on the contralateral leg. He has also drawn attention to conjugate deviation of the eyes and the turning of the head toward the contralateral side. In the majority of cases, owing to the extension of the tumor, there soon develops bilateral paralysis of the cranial nerves and the extremities, accompanied by dysarthria and dysphagia. Less often owing to extension, pressure, or location in the dorsal region of the pons, we may have sensory disturbances, hemiataxia, or convulsions.

The tumors of the medulla have many symptoms in common with pure pontine tumors, except that they involve the eighth to twelfth nerves more prominently giving rise to deafness, difficulty in swallowing and respiration, hiccough, dysarthria accompanied by irregular heart, and at times glycosuria, diabetes insipidus, and vasomotor phenomena. Pressure on the cerebellum may produce cerebellar symptoms.

Cerebral Peduncles.—*Tegmental Region.*—Due in all probability to involvement of the red nucleus, we have here the so-called "Benedikt's syndrome" consisting in an ipsolateral paralysis of the third nerve with contralateral paresis accompanied by an intention tremor of the type of paralysis agitans or chorea, due to an interruption of the rubrospinal tract (Monakow's bundle). This tremor has been found in eight out of eighteen peduncular tumors reported. If the growth involves the median fillet, we have contralateral anesthesia.

Ventral Region.—Here we have incomplete third nerve palsy of the ipsolateral side, and contralateral hemiplegia—face, arm and leg—usually associated with spasticity. Owing to the close relation of the nuclei of the third nerve, the growth early produces a bilateral paralysis of this nerve (nine out of eighteen cases).

Corpora Quadrigemina.—These tumors generally involve the lateral geniculate body, the subcortical auditory center in the posterior corpora quadrigemina, the third and frequently the sixth nerves, and in addition in advanced cases press upon the cerebellar peduncles. The commonest symptom is a combination of bilateral ptosis with weakness of upward and downward movements of the eye and feebleness of convergence. The pupillary reflex may be sluggish or absent. Amblyopia or hemianopsia, due to injury of the external geniculate body, is frequently seen, or complete blindness may be present. The peduncular pressure gives ataxia on walking or standing with no loss of sensation. Deafness is less constant. Intention tremors, athetosis, and vasomotor changes may be seen, while nystagmus is common.

Hypophysis.—Tumors of the hypophysis give rise to symptoms first because of perversion of secretion, and second because of pressure upon adjacent structures.

Perversion of Secretion.—Our present conception of the functions of the hypophysis and consequently the symptoms due to their perversion is largely due to the painstaking work of Cushing, Crowe, and Goetsch, and their associates.

The work of Cushing and his monograph detailing his investigations —"The Pituitary Body and its Disorders"—will long stand as a monument to American scientific endeavor. He has subdivided and classified the functions of the gland although naturally there is still much uncertainty and controversy concerning them. Whether the symptoms may be due to a hyposecretion or hypersecretion or a dyspituitarism in various cases, must still be decided; also whether the anterior or posterior lobe or the pars intermedia may be the source in an individual state. It is manifest that there may be an excessive activity of one and a lessened activity of another at the same time. Lewis has drawn particular attention, and with justice it seems to me, to the function of the pars intermedia and attributes in great measure to this the functions assigned to the posterior lobe by Cushing. At the present time it seems justifiable to assign growth to the anterior lobe and functional changes; *e. g.*, fat deposit, polyuria, etc., to the pars intermedia or posterior lobe; a hyperpituitarism before the age of ossification of the epiphyses gives rise to gigantism and acromegaly; after ossification to acromegaly, accompanied by excessive growth of hair and overactivity of the sebaceous follicles in the skin, while the anterior lobe hypopituitarism is accompanied by lack of bony growth, absence of hair, and soft skin characteristic of childhood. Posterior lobe insufficiency (Cushing) produces adiposity, high sugar tolerance, subnormal temperature, slow pulse, asthenia and drowsiness. Polyuria probably accompanies changes in the pars intermedia.

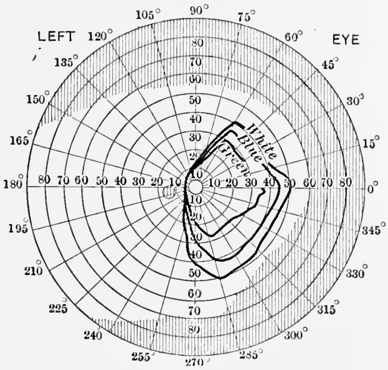


FIG. 97.—See Fig. 98. The right eye was completely atrophied. (Wesley Memorial Hospital, No. 46392.)

It is manifest that the clinical picture will vary with the type of tumor and as to whether it stimulates an excessive secretion or impairs the secretory activity (Figs. 97 and 98). Moreover, this picture may change from an excessive to an underactivity at any stage in the progress of the disease. We have, however, certain general symptom groups that accompany disease of this gland.

Froelich has classified the group accompanying certain preadolescent tumors, consisting essentially in a lack of development beyond the age of puberty—no growth of body hair, aplasia of the genitalia, with lack of function, lack of general bony growth—to which is added perversion of secretion producing an excessive deposit of fat. This type is frequently accompanied by cystic degeneration of the anterior lobe or anlage from the primitive pharynx lying in the sella turcica, but may accompany other tumors, such as adenomata. The adenoma, however, is more characteristic of the tumors developing later in life giving rise to gigantism and acromegaly characterized especially by excessive bony growth, hypertrichosis, excessive thickness of skin, excessive gland secretion supposed to be due to anterior lobe hypersecretion,

Fig. 98.—Hypopituitarism. Girl, aged eighteen years, cyst of hypophysis. No development after age of puberty, but no excessive fat deposit. (Wesley Memorial Hospital, No. 46392.)

followed by posterior lobe insufficiency, deposit of fat, high sugar tolerance, mental deterioration, etc. (Fig. 99).

The etiology of adiposis is still under discussion. It has been found accompanying tumors of the pars nervosa and the anterior lobe of the hypophysis, tumors in the neighborhood of the hypophysis, destruction of the hypophysis by a bullet, and not to be forgotten, accompanying hydrocephalus of the third ventricle produced by pineal, quadrigeminal, third ventricle, and cerebellar tumors. Pollock has drawn especial attention to the results of this latter type of hydrocephalus.

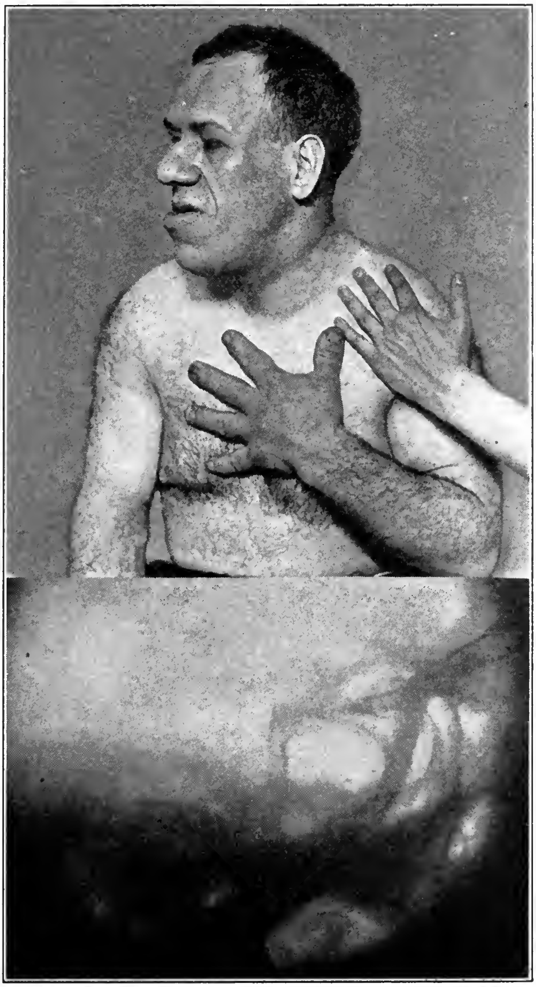


FIG. 99.—Acromegaly. Photograph of patient and sella. In spite of the evident enlargement of the sella and the marked signs of acromegaly no operation has been performed, since there is no impairment of vision and the disease has apparently been stationary for fifteen years. (Wesley Memorial Hospital, No. 53277.)

Certain hypophyseal tumors grow so rapidly as to produce only pressure symptoms (Figs. 100, 101 and 102), while on the other hand neighborhood tumors and those causing third ventricle hydrocephalus may produce functional changes as noted above, especially those due to posterior lobe insufficiency (Fig. 103.)

Pressure Symptoms.—Pressure upon the surrounding bony structures produces either an enlargement of the sella turcica or destruction

FIG. 100.—Sarcoma of hypophysis. Girl, aged fourteen years. Patient died six months after palliative partial hypophysectomy. Symptoms developed rapidly. No evidences of perversion of secretion. Early blindness and enlarged sella led to diagnosis. (Wesley Memorial Hospital, No. 47897.)

especially of the posterior wall. While tumors may grow out of the sella turcica without causing enlargement we are always loath to make a positive diagnosis without it. The enlargement of the sella practically always accompanies the Froelich type, and frequently the acromegalic. Sarcomata are apt to produce destruction of bone. An absence of the posterior wall of the sella turcica does not necessarily mean a sarcomatous destruction, since an aplasia due to pressure in early life may be seen. In sarcomatous destruction a fragmentation is often noted, but this also may be present as a result of benign growth.

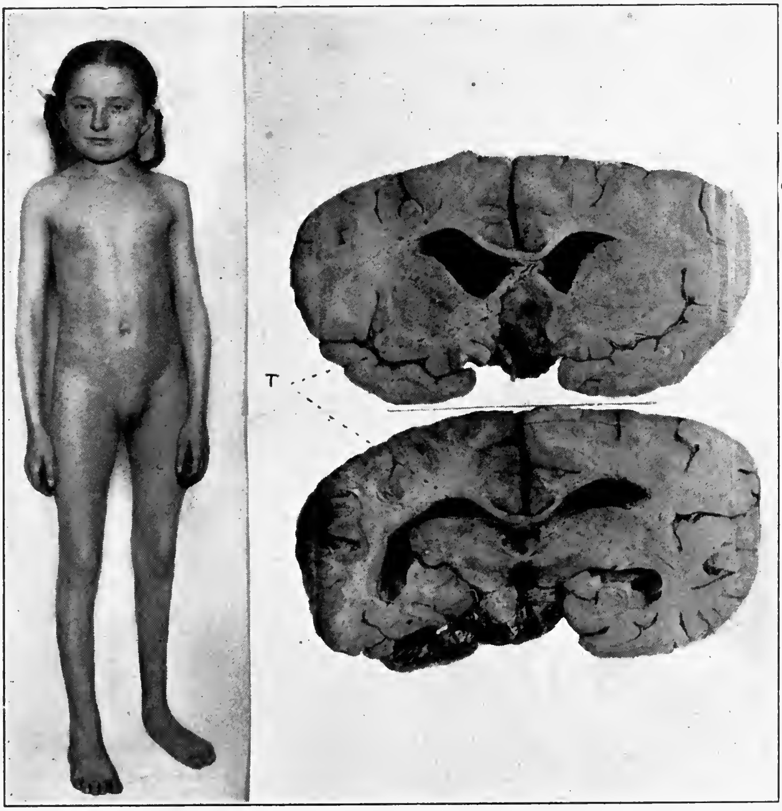


FIG. 101.—Glioma of hypophysis. Girl, aged fifteen years. Early blindness and change in sella, with lack of hair and other evidences of perversion of secretion, led to diagnosis. Convulsive seizures and marked brain pressure symptoms are explained by the growth of the tumor into the third ventricle (see cut section) and surrounding tissue with consequent hydrocephalus. (Wesley Memorial Hospital, No. 52242.)

The second most important symptom is pressure upon the optic nerve. Theoretically the tumor should produce, because of its location, a bitemporal hemianopsia, and while this frequently occurs, its absence does not contra-indicate the diagnosis. A glance at the accompanying chart modified from Stewart, will show how the picture may vary according to the pressure exerted (Plate III). There is frequently a history of transient attacks of blindness; amaurosis may be seen. These patients may first consult the oculist and because of the varying fields a preliminary diagnosis of hysteria is frequently made. Choked disk is uncommon, there being rather a primary atrophy of the nerve.

The involvement of other cranial nerves is fairly common. In 207 acromegalic cases Uhthoff found exophthalmos in 8 per cent.; muscle palsies in 10 per cent. The third nerve was involved in 23 cases, the sixth in four cases. In a series of 121 patients with tumor and without acromegaly, 25 per cent. showed muscle palsies; third nerve, twenty-six times; sixth nerve, seven times.

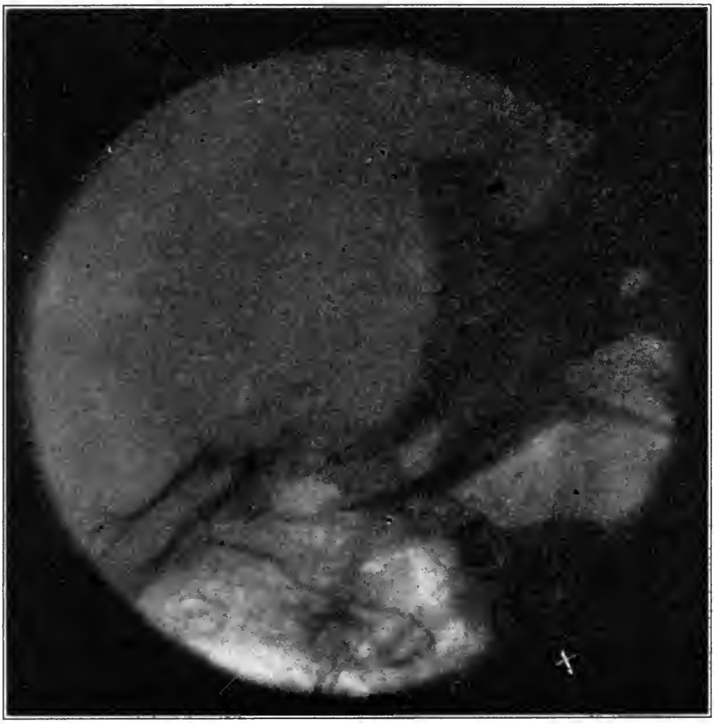


FIG. 102.—*X*-ray photograph of sella in case shown in Fig. 62. Note the absence of a posterior clinoid process. This observation led to a diagnosis of erosion by malignant growth. The autopsy showed that while the growth was malignant there was no erosion, the absence of the process being apparently congenital.

Pressure upon the cerebral peduncles will later cause accentuated knee-jerks and finally even more serious symptoms. This may follow from direct growth extending downward or, as in one of my cases, the tumor may invade the third ventricle and cause similar signs.

Pressure upon the uncinate process of the hippocampal gyrus may produce epileptiform seizures preceded by gustatory and olfactory sensations and a dreamy state.

Pressure upon the frontal lobes may be the possible cause of the mental deterioration seen in many cases.

Evidences of general brain pressure may supervene at any time, due to hemorrhage into cysts, to the growth of the tumor outside of the sella, or consequent ventricular hydrops.

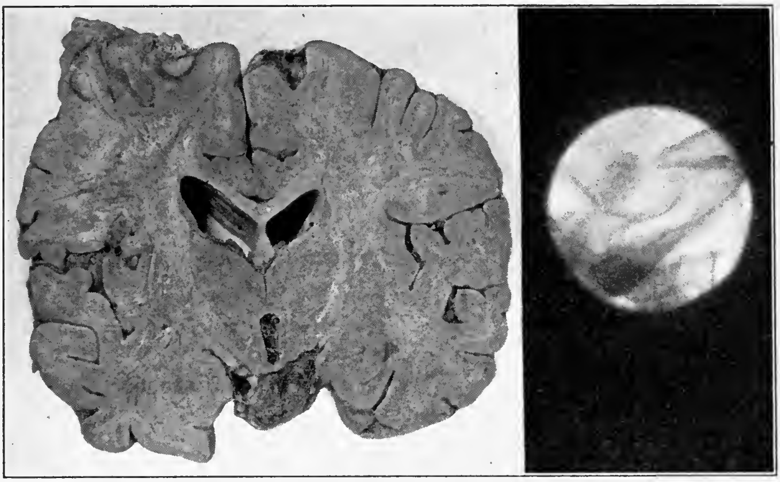


FIG. 103.—Brain and sella of patient presenting evidences of hypopituitarism. Excessive fat, little hair, etc. Patient died after two years' observation. Temporary relief was secured by corpus callosum puncture, subtemporal decompression having been of little value. Postmortem showed no tumor mass, but internal hydrocephalus, probably of inflammatory origin. (Wesley Memorial Hospital, No. 50909.)

PINEAL GLAND.—Bailey and Jelliffe have collected the reports of these rare tumors and classified the symptoms. The general symptoms of pressure are commonly present and the focal evidences are found in two groups: (*a*) the neurologic, (*b*) the metabolic.

The Neurologic.—These cases show not alone the evidences of general brain pressure and hydrocephalus, but also those findings peculiar especially to third ventricular dilatation, perversion of posterior lobe hypophyseal secretion, *v. s.* Pressure upon the corpora quadrigemina gives ocular and pupillary signs. Isolated nerve palsies are common. Nystagmus is not infrequent. Cerebellar symptoms arise from pressure upon the peduncles.

The Metabolic.—We commonly see adiposis, early sexual maturity and cachexia. Whether the adiposis is due to pineal perversion or to distention of the third ventricle and pressure with non-absorption from the posterior lobe of the pituitary gland may be open to discussion, but its presence is fairly common.

Gutzeit first drew attention to the early development of sexual characteristics with enlargement of the penis, general hypertrichosis, increased libido, and at times change of voice. Here, again, we do not know whether this is due to the inherent physiology of the pineal gland, to pressure, or to an irritation of the neighboring structures.

Visual Reflexes.—If we follow the optic nerves back from the eyeballs, we find that the nerves meet at the base of the brain and form the optic chiasm where a decussation takes place; the fibers from the temporal halves of the retina passing backward on the same side, and the fibers from the nasal haves crossing to the opposite side uniting with the opposite temporal fibers forming the optic tracts. Central fibers from the macula lutea pass into both optic tracts. These tracts wind around the crus cerebri to the primary optic centers, the external geniculate body, the anterior corpora quadrigemina, and the pulvinar of the optic thalamus. There arise also commissural fibers which pass forward and cross in the optic chiasm connecting the two internal geniculate bodies.

It is believed that the optic thalamus and the external geniculate body have to do with the reception of visual impulses and the forwarding of these to the cerebral cortex, while the anterior corpora quadrigemina are mainly concerned with the coördination of visual impulses and visual movements, and movements especially relating to the labyrinth and cerebellum. This is corroborated by experimental evidence in that stimulation of these bodies excites movements of the eyes and head and extirpation interferes with coördination but not with sight. Fibers arise from the optic thalamus and the external geniculate body and possibly also from the anterior corpora quadrigemina and pass backward through the hinder end of the posterior limb of the internal capsule to form the optic radiation and be distributed to the occipital lobes. The center in the occipital lobe is mainly, but not entirely, on the mesial aspect of the hemisphere and is divided into an upper and a lower part by the calcarine fissure, the cuneate lobe lying above and the lingual gyrus below. These two parts represent quadrants of the corresponding half of the visual field; *e. g.*, a lesion of the left cuneus will cause blindness of the right lower quadrant of both visual fields. Besides these centers, there is a higher center on the convex surface of the occipital lobe where a superficial lesion will cause not hemianopsia but crossed amblyopia, *i. e.*, a concentric contraction of both visual fields, more marked in the opposite eye. Also in right-handed people, there is in the left angular gyrus a center for the storage of visual memories of written and printed words, destruction of which produces word blindness (Stewart). The diagrammatic representation after Vialet (Plate III) shows the various types of blindness produced by lesions of given parts of the nerve and tracts. In addition to the coördinated movements governed by the anterior corpora quadrigemina, the centers for eye movements are found in the centers of the nerves, third and others, lying in the floor of the iter and the third ventricle. Stimulation of the back part of the third ventricle causes contraction of the pupil; of the corpora quadrigemina, dilatation: while stimulation along the floor of the iter produces contraction of the various eye muscles. Certain movements of the eye may also be produced by stimulation of the surface of the occipital lobe in the eye centers, a result brought about possibly through association fibers.

PLATE III

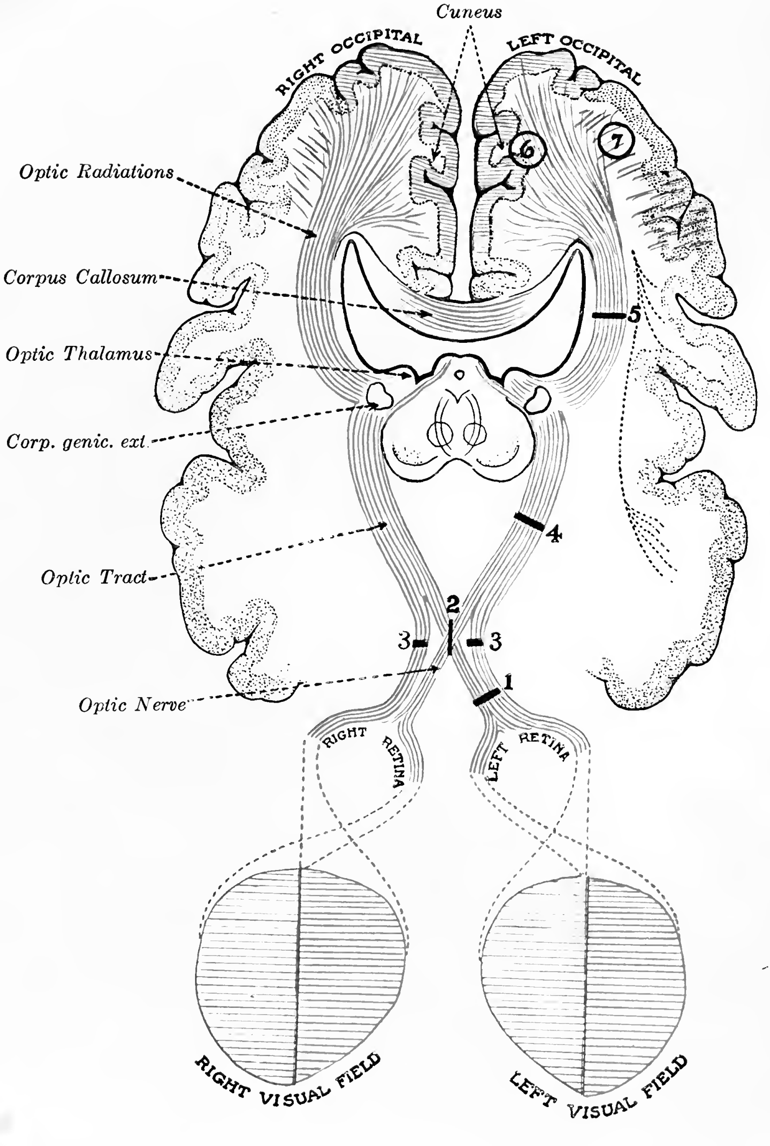


Diagram after Vialet, Showing Various Types of Blindness.

1, Blindness of One Eye; 2, Bitemporal Hemianopia; 3, Binasal Hemianopia; 4, Right Hemianopia with Hemiopic Pupil Reaction; 5 and 6, Right Hemianopia with Normal Pupil Reaction; 7, Crossed Amblyopia.

Relation of the Ear to Tumors and Abscesses of the Brain.—I am indebted to Dr. J. Gordon Wilson for the following discussion of the relation of the ear to tumors and abscesses of the brain.

The chief symptoms of lesions of the membranous labyrinth of the ear (including the VIII nerve) are deafness, tinnitus, vertigo, nystagmus and ataxia, with nausea and vomiting. These symptoms also may occur in lesions of the brain and so a differential diagnosis frequently has to be made. When the lesion is confined to the ear the diagnosis is as a rule easy. When the VIII nerve is involved directly, for instance, by pressure of a tumor in the internal auditory meatus, the diagnosis may be more difficult. When the lesion involves the labyrinth and a lesion secondary to it in some part of the cranium, *e. g.*, an abscess, the location of the abscess may involve considerable difficulty. Yet there are certain broad lines which taken together offer a basis for an accurate diagnosis. The history of the case and the involvement of other cranial nerves should those be present are of very material assistance.

Deafness.—Deafness may occur not only from involvement of the termination of the auditory nerve in the labyrinth and its central connections but also from disease in the conducting mechanism in the external meatus and middle ear. This preliminary separation of deafness due to disease in the conducting mechanism from nerve deafness is made by tests well known to otologists but because of the frequency with which both are involved no hard and fast distinction can always be made. When we try to locate the defect in hearing in some part of the nerve or of its central connections we are met with great obstacles unless we are aided by some concomitant symptom such as pressure on the seventh nerve, involvement of the vestibular mechanism, etc.

Nerve deafness may occur from a lesion in the cochlear branch of the eighth nerve or in its central connections. A gross lesion of the eighth nerve previous to entering the brain will almost certainly involve the vestibular branch of the eighth and very often the seventh cranial nerve. As the cochlear nerve decussates early and is widely distributed a lesion of the brain resulting in total deafness will rarely occur unless we have a very considerable lesion. Thus deafness may be due to disease in the temporal lobes but can only be considerable if the auditory sphere of both sides be involved. In short, deafness is often difficult to definitely locate and so it becomes only an important accessory in locating a lesion.

Tinnitus.—Tinnitus the sensation of noises in ear or head, is a frequent symptom of all forms of aural complications. Tinnitus may not cease after destruction of the labyrinth or section of the eighth nerve. It is difficult to estimate because its phenomena are purely subjective. It has little diagnostic value unless it be directly related in its time of appearance and in its intensity to a cranial lesion.

In disturbances of the vestibular mechanism—nystagmus, vertigo and ataxia—we have symptoms that lend themselves more definitely to observation and to estimation. As these three symptoms are frequent in cerebellar disease and as it is from lesions of the cerebellum that one has most commonly to separate labyrinthine disease, we may confine our observations chiefly to the differential significance of these symptoms in labyrinthine and in cerebellar lesions. It may here be noted that a slowly progressing disease of the vestibular mechanism may present no symptoms; and in the diagnosis the otologist may have to depend on tests for the physiological activity of the labyrinth, *e. g.*, the caloric and rotation tests. A sudden onset or marked acceleration of vestibular disease always is accompanied by the above symptoms.

Nystagmus.—Nystagmus or oscillation of the eyes occurs in various diseases of the brain, *e. g.*, in tumors of the posterior corpora quadrigemina and cerebellum; also in peripheral eye lesions and in labyrinth diseases. In a considerable number of normal individuals a slight spontaneous nystagmus is present in extreme lateral position of the eyes and has no pathological significance. Marked spontaneous nystagmus on looking to the side and even slight nystagmus on looking straight forward is pathological.

Nystagmus occurring in a labyrinthine lesion consists of two phases: a slow lateral deviation, labyrinthine in origin, followed by a quick return movement, cerebral in origin, synchronous in both eyes. It is decreased or even arrested by looking in the directions of the slow phase, it is increased by looking in the direction of the quick phase. By the use of suitable lenses which reduce or eliminate fixation, labyrinthine nystagmus is increased or even made to appear. The only cranial lesion that gives an identical picture is one involving the central connection of the vestibular branch of the eighth nerve, to the eye nuclei, for instance, a lesion of Deiter's nucleus and of the posterior longitudinal bundle. The slow phase in labyrinthine lesions is toward the side of the lesion. Exceptions to this rule may arise from irritation (not paralysis) of the vestibular nerve somewhere in its central course. So far as the otologist is concerned, dealing with the terminal organ, it only arises in connection with a well marked inflammatory lesion in the ear involving the petrous temporal bone and the vestibular nerve. In labyrinthine lesions the nystagmus with the slow phase to the side of the lesion varies in intensity during the first few days then gradually diminishes. If it persists unaltered for several days it points to involvement of the vestibular nerve.

Cerebellar nystagmus consists of movements which are ataxic in character. With the eyes at rest it tends to lessen or disappear but is increased by fixation. The plane in which the nystagmus moves as well as its intensity varies from time to time. It also frequently shows a slow and quick phase—the slow phase may be away from the side of the lesion or toward it, according to whether we are dealing with an irritative or a destructive lesion.

In short, labyrinthine and cerebellar nystagmus differs in uniformity of direction and in character. Not all cerebellar lesions produce nystagmus and, further, it is possible for a cerebellar tumor to produce the labyrinthine type by pressure on the vestibular nerve or the vestibular path in the pons.

Vertigo.—Vertigo is one of the most general symptoms of brain disease. The little appreciation of its value in diagnosis may be due to a failure to appreciate its significance and the wide application of the term to symptoms of very different kinds. It is applied to a variety of subjective sensations and even from intelligent patients it is very difficult to get a clear account of these sensations. The more severe symptoms of vertigo are associated with disease of the labyrinth and its vestibular nerve; and of the cerebellum with its peduncles. These are frequently associated with objective symptoms of vertigo, instability, falling, etc. The most distinctive subjective sensation which the patient complains of is the apparent rotation of himself or of external objects. In labyrinthine disease the apparent rotation is directly related to the nystagmus, it is in the direction of the quick phase and the direction of falling is in the direction of the slow phase. There is not the same uniformity in cerebellar disease and the rules suggested by Stewart and Holmes are only to be regarded as valuable suggestions. Attacks of vertigo with its objective symptoms caused by labyrinthine lesions gradually disappear as the acute attack passes off. In neurasthenia they may persist for a long time but gradually lose their distinctive labyrinthine character.

Disorientation and Ataxia.—In both cerebellar and labyrinth lesion there is a deviation in walking toward one side—to the side of the lesion if unilateral. This the patient corrects when the eyes are open. But with the eyes shut, when the patient recognizes the deviation he may deviate to the other side. Especially in cerebellar cases he is very apt to overcorrect. Romberg's sign is present in labyrinthine disease. It is rare in atrophy and sclerosis of the cerebellum; it is frequent in abscesses, tumors or lesions which from their nature are prone to affect other structures. In labyrinthine lesions in the Romberg position the patient falls in the direction of the slow phase of the nystagmus and if the head be turned he will fall backward or forward but still in the direction of the slow phase. This relation of falling to position of the head does not exist in cerebellar disease.

Dysmetria.—Dysmetria is not present in labyrinth disease. The muscular failure in labyrinthine cases is due to a failure of accurate perception of changes of the head in space resulting in a maladjustment of muscles to maintain equilibrium and direct orientation. The drunken gait of the cerebellar patient is not pronounced in labyrinthine disease.

In addition the otologist has at his disposal direct functional tests for labyrinth activity in the rotation test and the caloric reaction which afford information in regard to the physiological activity of the labyrinth. A discussion of these is not called for here. The above account is necessarily brief. Little has been said of those complex cases which involve both the eighth nerve and the cerebellum. Detailed information in regard to such cases and to functional testing must be sought for in the numerous articles available.

Conjugate deviation of the eyes and head toward the same side is found in disease of the cerebrum which commences with paralysis of the opposite side of the body, in which case, especially at the onset, the head and eyes are often deviated toward the side of the lesion; *i. e.*, away from the paralyzed side. In spasmodic conditions the deviation is toward the same side. The sign is seen especially in lesions of the first and second frontal convolutions, but may be seen elsewhere (*e. g.*, angular gyrus, occipital lobe, etc.). In pontine disease the eyes deviate toward the same side as the paralysis, due probably to involvement of the crossed posterior longitudinal bundle.

Another important finding is that of *astereognosis, i. e.*, the loss of the power to recognize the form and shape of objects by palpation. This condition may be due to tactile anesthesia, but generally represents a combined psychophysical act, in which association fibers come into play. Astereognosis may be due, therefore, to lesions of the post-central convolutions, to lesions behind it (Wernicke), or to lesions in the parietal lobe (Oppenheim, Bruns, Mills, etc.).

General Symptoms and Signs of Brain Tumor.—These are due to an increase in intracranial tension, produced both by the growth of the tumor and the improper circulation or increase of the cerebrospinal fluid. The most important of these are: choked disk, headache, and vomiting; and to these must be added slow pulse, vertigo, stupor, and convulsions. It should be remembered that the triad may be produced by nephritis, severe anemia, lead poisoning, and less frequently by other causes.

Choked Disk.—This is found in 90 per cent. of the brain tumors at some time in their course. Early transient dimness of vision is common, and a certain degree may be present with perfect vision. Frequently the congestion is greater upon the affected side, although both eyes are generally involved. In cerebellar tumors, choked disk is especially early in onset, due to overfilling of the ventricles with fluid. The choked disk is followed in time by atrophy with its persistent blindness although one may regain a certain amount of vision in almost hopeless cases if some vision is still present. In tumors pressing directly upon the nerves, the atrophy may progress without noticeable congestion at any time. This is seen particularly in hypophyseal tumors. Cushing has laid particular stress upon the interlacing of the color fields, saying that it is present in 40 per cent. of the cases. This has not, however, been of much diagnostic importance in the experience of the author.

Headache.—This is the most constant symptom, and is often of great severity, consisting of a constant dull ache, accompanied by exacerbations. This latter is an important observation, since the former may be due to many causes. The patient is little relieved by treatment. The headache is generally diffuse, but may localize, although localization is not diagnostic except where the tumor is near the surface and the localized headache is accompanied by localized tenderness of the skull, and even in such instances it may lead to error; cerebellar tumors may produce frontal headache. Anything that increases cerebral hyperemia, *e. g.*, exertion, excitement, coughing, will increase the headache. Von Bruns has noted that tumors of the posterior fossa produce morning headache due in his opinion to the congestion incident to the recumbent position. If the headache in the back of the head is accompanied by stiffness of the neck muscles, it speaks somewhat for a tumor there.

Vomiting.—This is not constant, but is present in a majority of cases, and is most constant in cerebellar tumors. It follows the headache and is often projectile in character, and may or may not be accompanied by nausea, occurring independently of the taking of food and without relation to gastro-intestinal disorders.

Slow Pulse.—This is a valuable sign when present. It may be transient or permanent, and is usually a late sign. It falls to 48 or less and may be accompanied by Cheyne-Stokes breathing, yawning, and hiccough.

Stupor.—This may be preceded by a progressive mental change. The patient is apathetic, answers question slowly, and finally passes into a stupor in which he may lose control of the bladder and rectum.

Vertigo.—One finds vertigo most commonly associated with tumors involving the cerebellum, cerebellar peduncles and the corpora quadrigemina, but it is associated with certain other basal tumors involving these areas secondarily and the vestibular nerve or its ganglia. Bruns has noted its presence in cysticercus of the fourth ventricle. The vertigo is more often a confusion such as is seen in intoxication; real giddiness and falling down is less common. It is seen at times associated with paresis of the eye muscles, due to close association of their centers with Deiter's nuclei. A more detailed discussion of its relation to cerebellar disease and otitic processes will be found in the sections dealing with these diseases.

Convulsions.—We distinguish here the Jacksonian type due to primary involvement of the motor area. As a sign of general increase of intracranial tension, they appear late, although they may be the earliest evidence, and one must wait for choked disk and other evidences of tumor before idiopathic epilepsy can be excluded. They are seldom of localizing value.

Diabetes, polyuria, polydipsia, genital changes, adiposity, etc., may be seen, but are to be considered rather under local signs. Auscultatory changes—the cracked pot in fractures or in the skull which has separated along the fissures, and bruit in aneurysms may be heard; indeed, the bruit may be heard in other conditions; *e. g.*, in infants and where the vessels are compressed by a tumor. It may be heard only by the patient as a subjective sensation. Tympany on percussion may be noted where the skull is much thinned.

The *differential diagnosis* must take into consideration the many diseases that will produce the general sign of tumor, *e. g.*, nephritis, lead poisoning, multiple sclerosis, epilepsy, paretic dementia, abscess, gummata, and finally the so-called pseudo-tumor, in which little or no pathology may be found at postmortem. At times an acute hydrocephalus may be seen that may be relieved by lumbar puncture or a localized ependymitis of the Sylvian aqueduct with resulting distention of the ventricles.

It should be remembered that gummata may resist syphilitic treatment. Sudden apoplectiform seizures in the course of cranial disease may be seen in gliomata. It has happened to the author to operate upon one case while the hemorrhage was active and the preoperative diagnosis was made because of the complication.

Abscesses generally give a history of some possible primary source and in the acuter forms we have a leukocytosis. Tubercles frequently occur at the cerebellopontine angle and adjacent areas. Gliomata originate in the brain and do not involve the meninges or bone while the sarcomata originate in the meninges or bone and compress or involve the brain-tissue. The gummata and tubercles may resemble each other on superficial examination and a microscopic examination be necessary to differentiate them. Gliomata appear especially in order of frequency in the hemispheres of the cerebrum, cerebellum, and pons; the solitary tubercles in the pons, cerebellum, or cerebral cortex; the gummata generally in the cerebrum; sarcoma in the meninges, bones of the base, parietal and sphenoid especially. The gliomata grow slowly and the sarcomata rapidly. Gummata have rapid growth and sudden recession. The gliomata and sarcomata are single and the tubercles and gummata may be multiple.

Cysts may occur as a result of parasitic growth (echinococcus or cysticercus) or trauma. The first will have the history of the disease in some other part of the body, and the latter a history of injury. At times they have origin in a hemorrhage into a glioma. Von Bruns has studied particularly the occurrence and signs of cysticercus in the fourth ventricle.

Carcinoma is generally secondary but may occur in connection with the choroid plexus. Cholesteatoma, psammoma, fibroma, and lipoma, are uncommon. Endotheliomata are fairly common, developing from about the vessels of the meninges.

Lumbar Puncture and the Cerebrospinal Fluid.—As a means of diagnosis an examination of the cerebrospinal fluid is of considerable importance. Unfortunately, the findings are not pathognomic, but must be correlated with the clinical data. Therefore, a just appreciation of the value comes only after considerable bedside experience. We cannot expect the laboratory to report that this or that patient has a gumma, tumor, or meningitis.

There is some therapeutic value to puncture in certain types of brain pressure, unfortunately generally transitory, although in my experience certain cases of vertigo and tinnitus have been relieved over a considerable period.

Some danger is to be feared in tumors so located as to impinge on the cord or medulla at the foramen magnum, since the latter may be compressed and cause sudden death. Where there is cause to fear this, and indeed, in all brain tumors, it is advisable to withdraw fluid slowly, and to place the patient with the head lower than the body. The possibility of infection is slight if care is taken, and the same may be said of injury to nerves. It is advisable to have the patient rest for twenty-four hours after the puncture, especially if headache develops. Where a small amount of fluid is withdrawn this is not necessary. Ten cubic centimeters may be removed without anxiety, and I have often taken forty slowly, without injury. The fluid is rapidly replaced.

Technic.—The skin is sterilized and cocainized, and the patient placed preferably upon the side with the back bent, the thighs flexed up toward the flexed head. If brain tumor is not suspected, a sitting posture renders the operation less difficult. The point of choice for puncture is between the third and fourth, or better, the fourth and fifth lumbar vertebræ, determined by drawing a line between the crests of the ilia. A small sharp, unrusted needle, the lumen of which has been tested, about 8 cm. long, is chosen. The surgeon places the ball of the thumb upon the spine of the fourth lumbar vertebra and at the lower and outer angle; *i. e.*, one-half inch outside and below the spine, the needle is inserted upward and inward at such an angle as to reach the center at a depth of about two and a half inches. Here the needle strikes the ligamentum subflavum between the vertebræ. This slight resistance is overcome and the needle immediately enters the subarachnoid space and the spinal fluid begins to drop out. If we strike a lamina, the needle is withdrawn slightly and inserted above or below. After feeling the sudden penetration through the ligamentum subflavum, if the fluid does not flow, a stylette is passed to clear the lumen of any clot of blood or push away a nerve that may be blocking the needle. If no fluid escapes, we may puncture at the next space above. The procedure should be carried out with as little trauma as possible, since the presence of blood interferes with our tests. If some blood does appear, it may be clear after a few drops. If it does not become clear, a second puncture should be made higher up, since a delay until another day may result in slight local inflammation that will also impair the accuracy of our findings. Indeed, some days must elapse before we are sure of securing a clear fluid.

The cerebrospinal fluid is absolutely clear, colorless, and of a specific gravity of 1005 to 1008. It is alkaline and contains a trace of serumglobulin and albumose and also will reduce Fehling's solution. Microscopically a few large endothelial plates will be seen and in the centrifuged specimen a few lymphocytes, three to five to the cubic centimeter. The presence of blood in the serum impairs the value of the microscopic and chemical tests.

The *pressure* of the fluid should be noted. This can be approximated clinically by always using in our puncture the same size of needle and placing the patient in the same position. We may measure it by attaching a rubber tube and a manometer to the needle.

The *color and clarity* are important findings. If blood be present it may come from the local trauma or a skull fracture or subarachnoid hemorrhage. If the blood is from a preëxisting subarachnoid hemorrhage, cerebral or spinal, we may determine this at times by centrifuging, since a fluid will remain yellowish and not present the clear limpid serum characteristically found when freshly mixed blood and serum are treated similarly. It may be turbid or purulent from acute meningitis.

Microscopic examination reveals the presence of lymphocytes, polymorphonuclear leukocytes, blood, and bacteria. The number per cubic millimeter and character of the cells should be noted.

The *chemical characteristics* have been extensively studied. An increased serum albumin content may suggest spinal tumor, meningitis, etc. Various tests for the globulin have been devised, such as the Noguchi butyric acid or the Nonne ammonium sulphate, Lange's colloidal gold reaction, the Ross-Jones ammonium sulphate tests.

Wassermann reaction for syphilis may show in the fluid when it is not evident in the blood.

The clinical deductions of the tests are, as noted above, relative rather than absolute. In general it may be said that slowly growing, chronic meningeal inflammations due to various causes and tuberculosis and syphilis will produce excessive globulin and an increase of lymphocytosis, while the more acute inflammations give rise to polymorphonuclear deposits and excessive globulin. Varying with the severity and stage in any individual disease, the picture may be different.

Tuberculous meningitis shows a high lymphocytosis, even running into the hundreds per cubic millimeter. The polynuclear element may be marked in the acute cases. Fehling's solution may or may not be reduced. There is a positive globulin reaction, but the fluid is generally not turbid as in acute meningitis. Careful examination of the coagulum that settles out after some hours will frequently show tubercle bacilli.

Acute meningitis shows a turbid fluid with many polynuclear leukocytes, some lymphocytes, globulin, lack of Fehling reduction, and the typical organisms.

Syphilis presents a varied picture, corresponding to the stage of the disease: the more acute processes presenting the leukocytes and lymphocytes, globular reaction, and a Wassermann reaction. As the disease progresses to the stage of tabes and such chronic conditions, the leukocytes decrease, the lymphocytes increase and then decrease, the globulin ultimately disappears, and the Wassermann cannot be obtained.

Brain tumors may produce no changes in the fluid, but in certain cases where the meninges are irritated, *e. g.*, cerebellopontine tumors, the cell count may be increased and the globulin tests be positive.

Radiology in Brain Tumors and Abscesses.—In tumors of the hypophysis, in abscesses following destruction of the mastoid, and in calcified tumors, the surgeon receives great help from the *x*-ray. The changes in the sella turcica in hypophyseal disease probably are of greater importance than any other sign. They consist of enlargement of the sella or destruction of the walls. The enlargement finds its best type in the adipose genital form of the disease when the slow growth in bone not yet fully calcified permits extensive distortion and new growth of bone. This is true in a lesser degree of the changes occurring in adenomata growing later in life. Here we may have either enlargement or destruction, or both. The destruction involves particularly the posterior clinoid processes and the wall between the sphenoid cells and the sella. In younger individuals there may be an absence of the posterior wall giving rise to an erroneous diagnosis of sarcoma, since the absence may be due to early pressure with aplasia of the wall. The malignant growths cause destruction and here the fragmented wall may be seen, although it has been my experience to find this same destruction in benign tumors.

Destructive processes, especially of the mastoid, may be seen and direct us to the diagnosis of an abscess. Less often may be seen calcified tumors and cysts, exostoses pressing upon the brain, sarcomatous or carcinomatous destruction of bone, and aneurysms (Fig. 104).

Fig. 104.—Osteoma of skull. These excessive bony deposits may at times conceal an endothelioma of the meninges; therefore, the surgeon should always examine the underlying structures.

Where tension is great in young individuals a separation or widening of the fissures may be noted with a deepening of the fossæ or of the venous sinus and emissary vein canals. The dilatation of the venous canals may be more apparent than real, since the veins engorged with blood magnify the enlargement. These signs are for the most part general; exceptionally, they may be of localizing value.

The manner of taking the pictures is of great importance. Miss Brindley at the Wesley Memorial Hospital Laboratory has made a special study of this matter in my cases, and has been enabled to secure most excellent pictures by paying great attention to placing the skull directly parallel to the plate. Care is taken to see that the occipital protuberance, nasion, and the sagittal plane of the head at the vertex, are the same distance from the plate. A diaphragm picture is then taken. Absolute superposition of the parts is necessary for sella turcica pictures. Whenever the picture is not clear, stereoscopic plates are made. These are always made where there is a question of destruction or of hyperplasia of the skull proper.

THE TREATMENT OF BRAIN TUMORS.

Craniocerebral Topography (Plate IV) —The surgeon should so familiarize himself by cadaver study with the general appearance of the fissures and convolutions as to enable him to recognize them at sight. He should also be able to visualize the parts of the brain under the unopened skull and also the relation of the ventricles to the various convolutions he may have in sight. The general relations of the brain to the cranial bones are as follows: The frontal bone covers the greater part of the frontal lobe and the whole of the lowest convolution. The posterior parts of the other convolutions are covered by the parietal bone. The frontal eminence marks the second convolution. The antero-inferior angle of the parietal indicates the inferior frontal convolution. The parietal bones cover the posterior ends of the upper two frontal convolutions, the central convolutions, and a part of the occipital lobe. The parietal eminence corresponds to the supramarginal gyrus. The central convolutions lie more on the top of the brain than the side; hence are under the upper part of the parietal bone. The posterior arm of the Sylvian fissure ends just below the parietal eminence, and is therefore higher than one would think. The temporal bone covers the greater part of the temporal lobes; the highest point of the squamous suture lying over the Sylvian fissure. The temporal muscle covers the temporal lobes, lower frontal convolutions and the Sylvian fissure. The zygoma is on a line with the floor of the middle cranial fossa; hence the lower level of the temporal lobe.

Reid, Thane, Horsley, Kroenlein, Froriep, and many others have attempted to establish measurements that would accurately outline the various lobes. Owing to the special importance of localization in the motor zone, these surgeons have placed especial emphasis upon the position of the Sylvian fissure and the central sulcus. The investigations of Sherrington which have placed the motor centers in the precentral convolutions have simplified the mensurations necessary since, as Kocher has shown, a line drawn from the midpoint on the sagittal line from the nasion to the occipital protuberance downward and forward at an angle of about 60 degrees to the midpoint of the zygoma roughly indicates the direction of the top of the precentral convolution. I use this method in ordinary cases. Where more comprehensive knowledge is needed, the Kroenlein method is probably as satisfactory as any

PLATE IV

FIG. 1

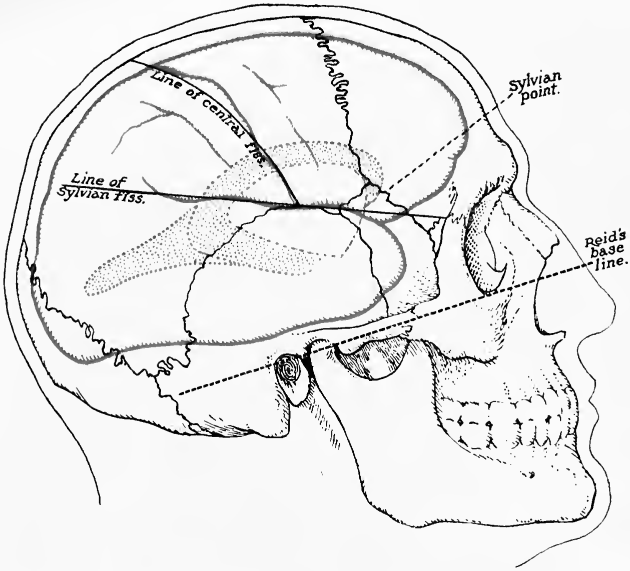
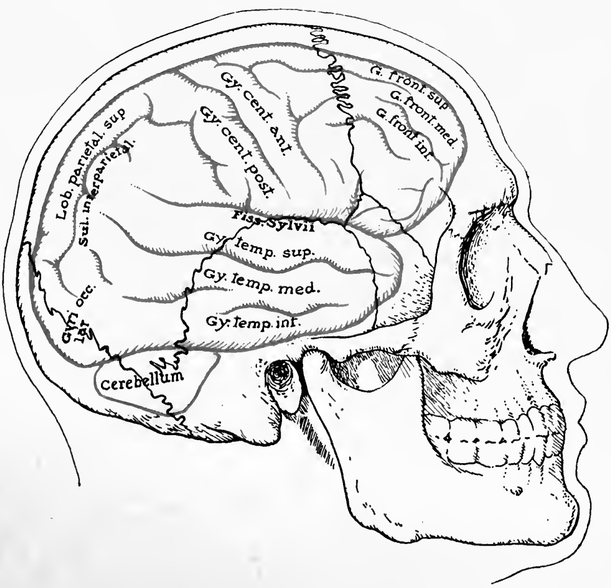
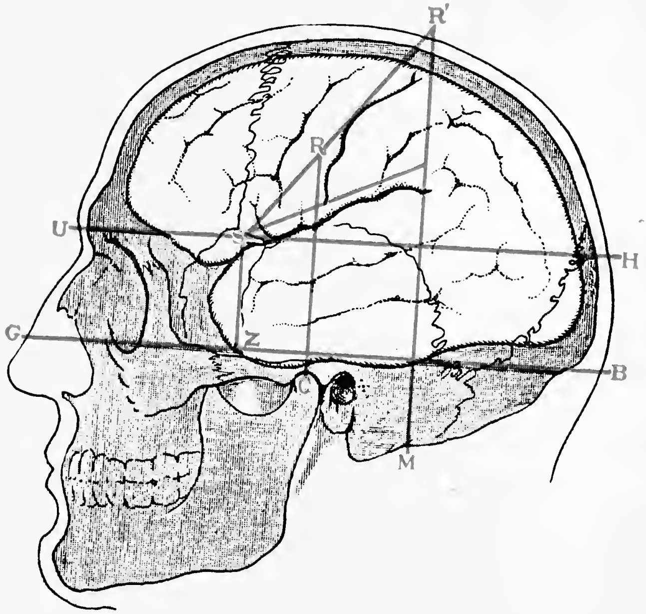


FIG. 2



Craniocerebral Topography.

PLATE V



Kroenlein's Method of Cerebral Localization.

(Plate V). By this a line is drawn through the inferior edge of the orbit and the upper edge of the auditory meatus. A second line is drawn parallel with this from the upper edge of the orbit. Three perpendiculars are now erected: one from the middle of the zygoma, one in front of the tragus, and one at the posterior border of the mastoid. The last is projected upward until it meets the sagittal line drawn between the nasion and the occipital protuberance. From this point, called the superior Rolandic point, a line is drawn forward and downward to the point where the upper horizontal meets the anterior perpendicular coming from the middle of the zygoma, this point being called the Sylvian point. The middle perpendicular from in front of the tragus is then projected up to meet this oblique line drawn between the superior Rolandic point and the Sylvian point. The point where this meeting occurs is called the inferior Rolandic point. The part of this oblique line between the superior and inferior Rolandic points indicates the central fissure, and hence the motor centers are in front and the sensory centers behind. If a second oblique line be drawn from the Sylvian point upward and backward, bisecting the triangle made by the Rolandic line and the upper base line, we have the line of the Sylvian fissure. The superior Rolandic point lies about $2\frac{1}{2}$ cm. back of the midpoint of the nasio-inionic line. These lines can indicate only relatively the position of the convolutions, since skulls vary in their configurations. However, they are just as satisfactory as the various craniencephalometers for which there is so little use that description is unnecessary.

Treatment of Tumors.—The technic of craniotomy is treated elsewhere, but it remains for us here to speak of the technic of removal of tumors in cases where it is possible to remove them. With the entrance into the field of the trained neurologic surgeon and with the introduction of methods comprising gentleness in handling the brain, care in preventing hemorrhage, and rapidity of operating, our results are growing better. Statistics show that permanent relief may be hoped for in from 6 to 8 per cent. of cases; marked relief in fully 30 per cent.; while in a majority of the remainder some temporary amelioration may be hoped for. The mortality of the operation itself in the hands of the skilled American surgeon has been much lower than in European clinics, the fatal cases being attributable in a large part to the late stage at which relief is sought, although there is still a considerable mortality incident to operation especially in cerebellopontine and hypophyseal tumors. While rapidity of operation has been mentioned as a desideratum, it is of small importance compared to nicety of technic and the prevention of hemorrhage.

Ether anesthesia is used for the most part although preliminary injection of the area with novocain and adrenalin seems to lessen the hemorrhage and may lessen the amount of anesthesia used. The field of local anesthesia is being widened constantly and it is possible to do many of these brain operations by this method.

The patient should be placed in as comfortable a position as possible not alone for the benefit of the patient, but particularly for the aid it gives the surgeon. The head should be higher than the body so as to lessen the hemorrhage and then reduce the intracranial tension. This can be produced by elevating the head of the table or by tipping the whole table, the patient being held in position by straps or supports. If the special tables devised for supporting the head and maintaining the body are available, so much the better.

The dura having been exposed, any large vessels that may bleed are ligated with the finest of catgut or silk, and the dura opened. Owing to the increased intracranial pressure, the brain will tend to bulge through the small primary slit in the dura, and great care must be used to avoid injury to the engorged pial veins which may give rise to embarrassing hemorrhage. Small pledgets of moist cotton can be laid against such an area temporarily, or small pieces of the patient's muscle-tissue may be held firmly in place at the site and when once agglutinated may be left.

Ample opening of the skull should be made immediately. The beginner is tempted to make a small opening and enlarge it where necessary, thus prolonging the operation, incising the dura disadvantageously, and adding to the shock.

Fig. 105.—Glioma with cyst formation.

Shock when it occurs is generally due to loss of blood or excessive traumatism, both of which are directly due to the surgeon's technic; therefore every possible precaution should be taken to prevent them.

Where the intracranial pressure is so great as to interfere with operative procedures, a puncture of the ventricle should be done. This will facilitate not alone the operative procedures upon the brain, but also will be of material assistance in closing the wound. Corpus Callosum puncture may be made and exceptionally, lumbar puncture may be resorted to, but one should always remember the especial danger that accompanies this procedure in the presence of brain tumors.

When the field is exposed, search should be made for the tumor. If it is upon the surface and is highly vascular, if its margins are ill-defined and of soft consistency, it is probably a rapidly growing malignant tumor or a glioma. It is the part of wisdom to let such tumors alone, for while it is justifiable at times to remove a small glioma in a "silent" area, we usually find that, added to the danger of bleeding and death, there is the probability that the tumor will grow more rapidly after attempts at removal. So marked is this tendency that some cranial surgeons make it a rule never to attempt to remove gliomata. Non-vascular cystic tumors may be gliomata lying somewhat dormant, into which hemorrhage has occurred (Fig. 105). Traumatism of these tumors also gives rise to rapid growth. If the growth is firm and sharply outlined the tumor is probably an endothelioma and operation is indicated. If the tumor lies below the cortex and can be felt but not seen, it speaks for a glioma which should not be operated upon except that, if cystic, it may be gently aspirated. If the tumor is well defined, however, it may be a cyst or abscess demanding removal. A consideration of the aspirated fluid may help us, but here much good judgment is called for.

Before we come to consider the special technic in the various lobes, it may be well to investigate the probable site and nature of the tumors. Tooth's tabulation of 500 cases reported at the Seventeenth International Congress is as follows:

TABLE I.

Region.	Sex. M.	Sex. F.	Total.	Per cent.
1. Frontal	60	40	100	21.7
2. Central pre- and postparietal	43	20	63	13.7
3. Temporosphenoidal	24	25	49	10.6
4. Occipital	8	6	14	3.0
5. Corona radiata, corpus callosum, etc.	4	6	10	2.1
6. Lateral ventricle	2	1	3	0.6
7. Pituitary	10	4	14	3.0
8. Optic thalamus	4	2	6	1.3
9. Mesencephalon	18	8	26	5.2
10. Pineal	4	...	4	0.8
11. Choroid plexus; III and IV ventricles	4	1	5	1.0
12. Cerebellum	44	33	77	16.7
13. Extracerebellar	19	21	40	8.7
14. Pons	19	24	43	9.3
15. Medulla	...	1	1	0.2
16. Base	1	3	4	0.8
Total	264	195	459	
17. Not localized	24	17	41	
Grand total	288	212	500	

Forebrain, 239, or 52 per cent.; midbrain, 30, or 6.5 per cent.; cerebellum and pons, 160, or 34.2 per cent.

Of the group shown as not localized, many are unquestionably located in the frontal and temporosphenoidal regions.

In regard to the age the author sums up as follows: Tumors of the forebrain tend to appear more frequently in middle-age, but no age is exempt. Those of the midbrain, on the other hand, are most predominant in the early or adolescent period, and the same may be said of tumors of the cerebellum and pons. Comparatively few occur here after thirty.

As to the variety of the tumor, gliomata comprised 127, or 49.2 per cent.; fibrogliomata, 15; fibromata, 13; endotheliomata, 37; sarcomata, 21; carcinomata, 15; tuberculomata, 14; simple cysts, 5; papillomata, 3; cholesteatomata, 2; pituitary tumors, 2; pineal gland tumors, 4.

Cancerous heredity was present in 37 cases, or 7.2 per cent. In no case was there any history of a brain tumor. Gliomata were well distributed throughout the brain, comprising 58 per cent. of all growths in the forebrain, 50 per cent. of those in the midbrain, and 38.4 per cent. of those in the cerebellum and pons. Fibrogliomata and fibromata were peculiar to the cerebellum, pons and medulla; endotheliomata occurred only in the anterior fossa of the skull. Sarcoma occurs in any portion of the brain. Of the 21 cases, 6 were undoubted round- or spindle-celled sarcomata and were secondary; the remainder of the cases were primary.

Of the 15 carcinomata only 1 was unquestionably primary. Primary tumors in 7 secondary cases were located; 3 times in the mammary gland and 1 each in the ovary, suprarenal, pancreas and rectum.

Cysts are said to be more common in the cerebellum than in other parts of the brain. Of these there are many varieties; parasitic, dermoid, serous due to transformation of sanguineous effusion or an area of softening or hemorrhage into a glioma; and cysts due to serous meningitis.

Operations upon the frontal lobes must take into consideration the extent of the frontal sinuses, since they may be a source of meningitis if the operation leads through them. *X*-ray pictures should be taken accurately outlining the sinuses before operation begins. Large tumors may be removed without doing serious permanent damage.

When the tumor lies in the paracentral lobules, great care should be taken not to destroy any more of the brain tissue than is absolutely necessary. Here especially one should be conservative in the treatment of the gliomata for fear that the final state of the patient may be worse than the present. If the cerebral tension can be lessened by a Cushing subtemporal decompression it is the operation of choice. Endotheliomata, tuberculomata and cysts should, however, be removed. One cyst that was removed by my colleague, Dr. H. M. Richter, had grown to such a size as to cause almost complete paralysis on the contralateral side, yet by gentle manipulation, the fluid was aspirated, and by grasping the wall of the cyst and twisting slowly the entire cyst sac was removed without hemorrhage and with an ultimate complete restoration of function. The adjacent brain tissue should be gently separated from the tumor mass by a spatula covered with moist cotton or wiping it off with the cotton-covered finger as the tumor is extracted. Violent tearing or cutting should be avoided. The tumor should never be "gouged" out. Care should be taken not to injure the blood supply along the central fissure. It should be remembered that the cortical 0.5 cm. is made up largely of association fibers and can therefore be cut with much more impunity than the lower lying pyramidal cell-bearing tissue.

The temperosphenoidal lobes are frequently the seat of tumors, and especially upon the right side may be removed extensively.

Tumors of the interior of the forebrain or midbrain and those involving the ventricles are inoperable, and are frequently best treated by puncture of the corpus callosum or this associated with a decompression

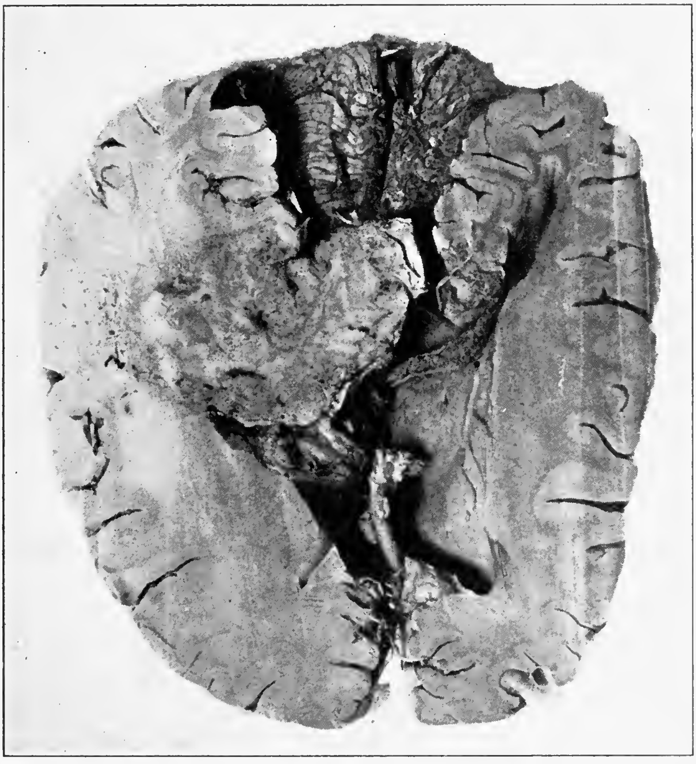


Fig. 106.—Central glioma producing marked hydrocephalus. (Northwestern University Medical School collection.)

(Fig. 106). When a tumor of the cortex is removed and the resulting defect connects with the ventricle, no alarm need be felt, but one may here interpose a pad of fat to fill the defect, being careful not to use too large a piece.

Tumors arising from the dura can be removed without difficulty either by peeling them off or removing the dura involved and transplanting a flap of fascia lata to take its place.

As mentioned above where a cyst sac can be removed, it should be done. If thin walled it may be removed by grasping the edges of the opening and twisting slowly and gently. If this is not feasible, the walls may be cut away; or if the wall is too thick for this, it should be curetted so as to thin it and favor collapse. The interior should be painted with iodine to further irritate the connective tissue and destroy any epithelial cells, so that union of the collapsed walls may take place. In exceptional cases drainage either into the subdural space or into the subaponeurotic space may be indicated. Elsberg suggests a strip of Cargile membrane for drainage material. The possibility of a cystic degeneration of a glioma should not be forgotten.

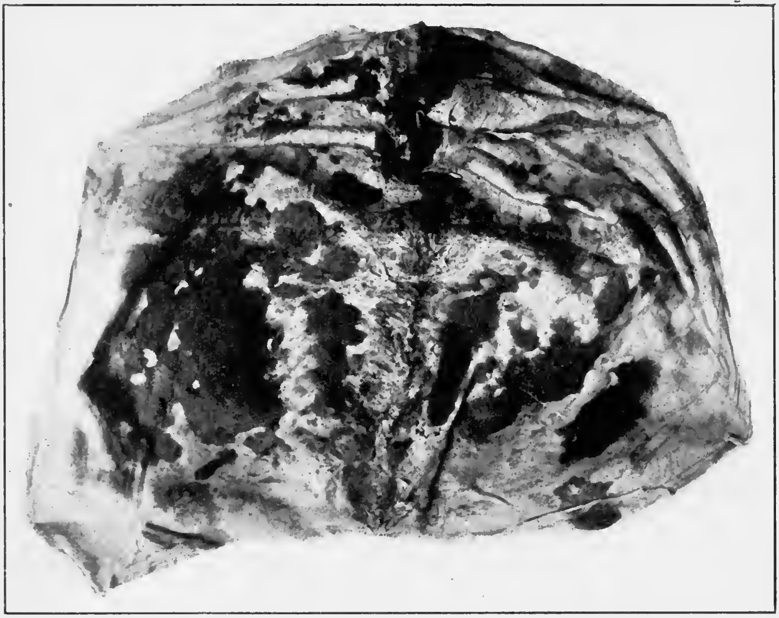


Fig. 107.—Chloroma of dura. The color cannot be shown in the photograph. (Northwestern University Medical School collection.)

Cerebellar and Cerebellopontine Tumors.—Operations upon the cerebellar region have two special dangers: hemorrhage and the possibility of involving medullar function producing sudden death. For these reasons such operations are looked upon with concern by the surgeon. The operations *per se* upon the cerebellum are not dangerous. Frazier says that the whole of a lateral lobe may be removed or destroyed without serious permanent injury to the patient, but after any operation edema and added pressure upon the medulla or the accumulation of large clots or the changed relations of the structures pressing upon the medulla or the forcing of it down into the foramen magnum, are sources of real danger. To obviate these it is wise to have the patient in such a position that the surgeon is master of the situation at all times. The lateral, head-up position of Frazier is very satisfactory, the patient being held in position by arm supports.

Cushing and others have advocated bilateral removal of bone below the transverse sinuses and in most cases the bone is not replaced. In most cases it may be advisable to remove the posterior portion of the bone about the foramen magnum. Manipulation should be made with care so as not to traumatize the pial vessels which will be engorged and bleed profusely if extra tension is present. Frazier has considered these operations in a masterful manner and has emphasized these points repeatedly, insisting that, if the tumors are malignant or adherent, no attempt at removal should be made, a decompression being the wiser procedure. Special warning against lumbar puncture should be given owing to the danger of driving the medulla down into the foramen magnum. He also does not believe that a bilateral operation is generally needed. Persistent drainage of cerebrospinal fluid may continue for some days from these wounds without serious consequences. If a cyst is found in the cerebellum it may be removed with especially good prognosis. The endotheliomata, fibromata, and neurofibromata that appear are most commonly found at the cerebello-pontine angle. Owing to their frequent origin from the eighth nerve, they are called acoustic tumors. They may be removed and at times permanent cure results. The mortality incident to the procedure has, however, been exceptionally high. Von Eiselsberg lost 13 out of 17 cases and as a result speaks against removal when the tumors are larger than a walnut, advising rather morcellation and partial removal. Other surgeons have had similar experiences. Marx collected 50 cases operated upon by the Krause technic showing a mortality of 70 per cent. The Borchardt (5 cases) and Panse (4 cases) operations have not been used often enough to give a correct idea of their value.

Krause does a unilateral suboccipital removal of the bone going down to the foramen magnum (Fig. 108). The dura is cut in flap form and the lateral cerebellar lobe gently retracted toward the middle and upward exposing the petrous portion of the temporal bone, this is followed inward until the tumor is exposed attached to the eighth nerve. The facial nerve generally lies upon the tumor and should be retracted to avoid injury. The tumor is gently enucleated by a thin blunt spatula, working the tumor upward and outward away from the medulla. Elsberg warns especially against the use of the finger. The gush of cerebrospinal fluid that appears on first exposing the tumor need give no alarm. The tumor having been removed, the area is dried, the lateral lobe allowed to fall back into position and the dura and muscles or muscles alone sutured. Frazier says that he has seen no bad consequences follow resection of a cerebellar lobe if this is necessary to give good exposure. Rather than do this, it may be wiser to make a two- or three-stage operation. This should be done in any instance where hemorrhage threatens serious consequences.

Panse suggested reaching the tumor directly through the mastoid and labyrinth (Fig. 109). With the labyrinth a large part of the petrous bone is removed and the dilated internal meatus exposed. Through this opening the tumor is curetted away. Schmiegelow has operated twice by this method and has had a recovery in both cases, and Kummell and Quix in two previously reported cases were also successful.

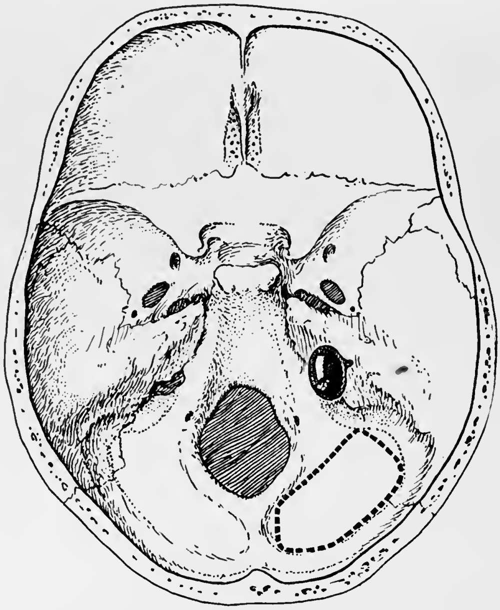


FIG. 108.—Krause operation for cerebellopontine tumor. Note the distance from the tumor.

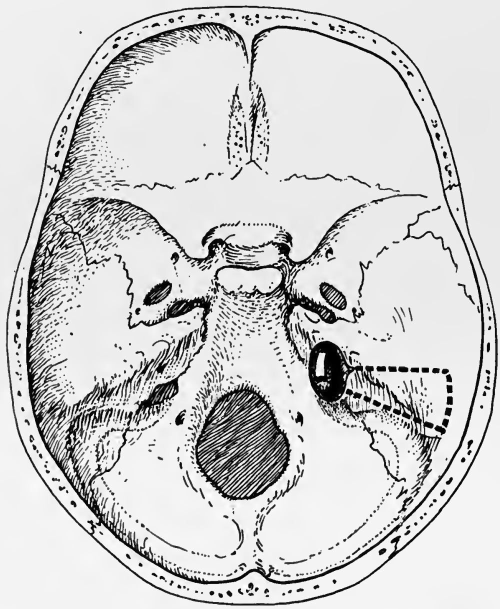


FIG. 109.—Panse operation for cerebellopontine tumor.

There is great probability of destroying the seventh nerve by this procedure, but in view of the gravity of the operation and the frequency of paralysis of this nerve previous to the time of the operation, the saving of this should not be a desideratum if further experience demonstrates its safety.

Borchardt combines the advantages of both of these procedures (Fig. 110). He removes the outer third of the occipital bone and the labyrinth and mastoid as well, thus securing a larger opening for work. This procedure necessitates ligating the sinus and cutting it with the dura. While the author has never attempted the Borchardt method, he feels that it has much to recommend it. The unilateral removal of the occipital bone has, however, in his hands been fairly satisfactory since

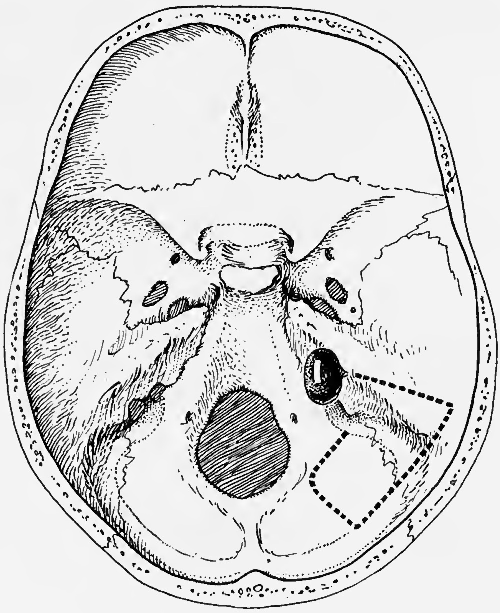


Fig. 110.—Borchardt operation for cerebellopontine tumor.

it permits of extensive dislocation of structures and provides ample room for subsequent edematous swelling.

Hypophyseal Tumors.—The reasonable certainty of accurate localization in hypophyseal tumors gives fair encouragement for operative relief in most and cure in some cases. Judged by the criterion of return to society as a self-supporting member, the results of treatment may be said to be better than in most other brain tumors. The work of Cushing, Frazier, Lewis, Elsberg, von Eiselsberg, Hirsch, McArthur, and earlier by Horsley and others, has been a bright page in the study of the treatment of these tumors. In spite of this, however, we are not able to count a large number of complete cures. The author has two patients who suffered from cystic disease who have been well now a number of years; one for over eight and one for five. Both are self-supporting members of society, neither has suffered mental deterioration, but neither has secured complete physiological restoration as to growth and sexual function. Von Eiselsberg, Hochenegg, and others report similar experiences.

The author has elsewhere discussed the various operative procedures and the following is modified from these various contributions. Many routes have been advocated for approach to the gland. The advantages and disadvantages will be discussed after considering the technical points as to the various routes.

The Intracranial Routes.—*Through the Middle Fossa.*—At the present time this route is not used by many. It was originally suggested by Caton and Paul and was used by Horsley in all of his cases. Dalgren, Cushing and others have attempted to follow the same route. The author has had no experience with it, but believes it is inferior to others because of its inherent difficulties and the fact that it does not expose the region as satisfactorily as does the frontal approach.

Through the Anterior Fossa.—To McArthur and Bogojowlensky should be given the credit of bringing again to the attention of the profession this route which had previously been suggested by Killini and Krause. The former proposed making a dural and bone flap and elevating the frontal lobe while Krause proposed an extradural route under the frontal lobe to the chiasm. The suggestion of McArthur to remove the orbital ridge in addition to the frontal bone is a landmark in this procedure. The operation was still extradural down to the optic chiasm. The ridge was removed separately from the frontal bone flap but was replaced after operation. Frazier modified this by leaving the orbital ridge attached to the frontal bone, and Elsberg, by adding that the flap should be made with its base inward, has made the approach nearly ideal for those cases in which the intracranial operation is chosen. Adson's technic of intracranial approach described later is also highly recommended. Elsberg's technic is described by himself as follows:

"*X*-rays having been taken to determine the size and extent of the frontal sinuses, the side of the frontal bone is selected in which the sinus is the smallest. If the patient has lost the sight of one eye, it is best to do the operation on that side.

"An incision is made from the inner angle of the eyebrow outward to the external angular process of the frontal bone, then upward and backward to within the hair line and then inward to near the median line. With an ordinary trephine, openings are made at the beginning of the incision, just above the external angular process and at the upper outer and upper inner angles of the incision in the soft parts. The bone is cut in the usual manner with Hudson forceps. The soft parts are slightly dissected down from the supraorbital ridge, the roof of the orbit about 1 cm. behind the supraorbital ridge divided by slight blows with a small chisel, the supraorbital ridge cut at each trephine opening with a Gigli saw or sharp Liston forceps, and the bone fractured toward the median line. On account of the thickness of the bone in the median line, it is usually necessary to partly divide the base of the bone flap with the cranial forceps (Fig. 111).

"With various rongeurs, the thin roof of the orbit is removed down to the optic foramen, care being taken that the direction of the rongeuring is correct so as not to open into the ethmoid sinuses, and that the periosteum of the orbit is not injured. As the operator approaches the optic foramen, a long-bladed rongeur must be used, the orbital contents depressed, and the frontal lobe in its dura slightly elevated. As soon as the optic foramen is reached, and after all oozing of blood has been controlled by gauze pressure, an incision about 3 cm. long is made from the exposed anterior clinoid process toward the median

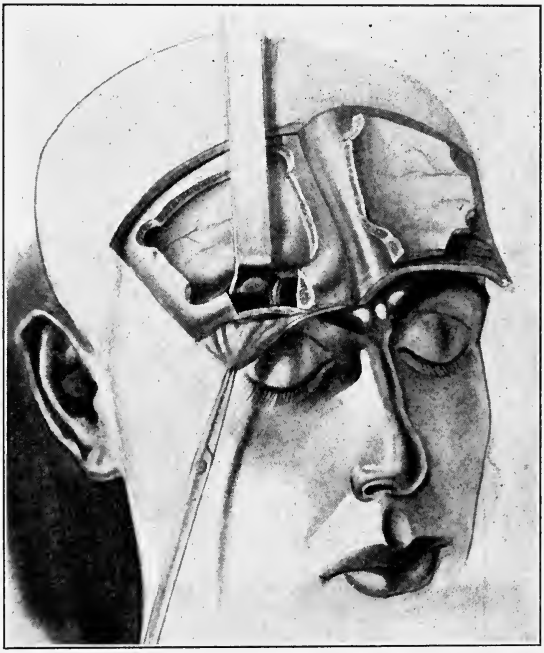


FIG. 111.—Technic of Elsberg approach. Drawing furnished by the kindness of Dr. Elsberg.

line, a small brain retractor introduced into the opening and the frontal lobe elevated. The optic chiasm, hypophysis, and sella turcica are now in good view.

"When the treatment of the hypophyseal lesion has been finished, the bone flap is returned into place and the soft parts sutured in the usual manner.

"The operation is not at all difficult in the hands of the surgeon experienced in cranial surgery, and an excellent exposure of the region of the hypophysis is obtained. It is possible to extirpate or partially remove a growth from around the pituitary body in full view, and the operation is surgically very satisfactory. The amount of elevation of the frontal bone that is necessary is not very great, so that no injury to the brain should occur. The orbital roof should be removed over an area about 2 cm. in width, and if an ethmoid sinus be opened it should be closed with a little Horsley wax. The supraorbital ridge forms part of the osteoplastic flap which is better than if the bone is removed in one piece and later replaced as in Frazier's operation. The amount of visible scar is very small, only a small line between the external angular process of the frontal bone and the hair line." (Fig. 112.)

In the author's hands this operation has been satisfactory in certain cases in which solid growth can be prognosticated. If there is much evidence of brain pressure, a corpus callosum puncture should be made previous to operation since excessive brain pressure adds materially to the difficulty. He has also used a much larger bone flap extending well

Figs. 112 and 113.—The patient was operated upon by the author after Elsberg's method. Note the manner in which the scar can be covered by the hair. (Wesley Memorial Hospital, No. 50909.)

back toward the motor area, combining with this a dural flap in some cases. If there is much brain pressure exceptional care should be taken to remove the orbital ridge with the skull flap; otherwise it will be difficult to hold the orbital section in place.

Adson has developed a more lateral approach under the frontal lobe. It is to be highly commended not alone because of the directness of the approach but also because of the adequateness of the primary bone flap. Frazier has lately advocated an intradural approach through the incision recommended by him, while Heuer and others have also suggested a return to this earlier method; but Adson has developed the operative technic and introduced many new features that highly recommend his procedure. I quote the following from his discription of the technic:

"The patient is placed on the operating table at an angle of 80 degrees with the horizontal plane. The head is held back in a position to permit the natural gravitation of the frontal lobe from the anterior cranial fossa. The anterior limb of the osteoplastic flap corresponds to the margin of the hairline, and this affords three-fourths inch of space posterior to the external angular process of the orbit, thus preventing injury to the motor branch supplying the frontal division of the occipitofrontalis and guarding against any paralysis of the muscle. The incision is carried upward to the median line three-fourths inch from the longitudinal sinus; it is then extended backward for a distance of three and a half inches and downward over the parietal eminence to a position above the middle of the ear.

"After the dura has been exposed a flap is made to permit the exposure of the frontal lobe, but it is made at right angles to the osteoplastic flap, which has been broken in the region of the temporal bone and turned downward. The dural flap is permitted to remain in position and to cover the cortex of the brain, and the frontal margin is raised by tension sutures of silk. The brain substance, as well as the exposed dural surface, is covered with warm, moist cotton, which, in turn, is covered by rubber tissue.

"In the elevation of the frontal lobe, rubber tissue strips are placed gently over the convolutions in a shingle effect in order to give a uniform pressure over the cortex as it is elevated by the retractor. There is very little difficulty with bleeding during this process; occasionally there is a small venous communication between the cortex and the dura. With gentle manipulation the optic commissure and the hypophyseal body are readily exposed. Important landmarks during the elevation of the frontal lobe are the anterior cranial fossa, the margin of the lesser wing of the sphenoid to the anterior clinoid process, the right optic nerve and the internal carotid artery. The procedure is then carried on mesially until the commissure as well as the left optic nerve and the hypophyseal body are brought into view. A gentle dissection of the tumor is then begun with blunt hooks to free it from the commissure, nerves, and surrounding tissue. Usually the tumor is definitely encapsulated, and if freed from the constricting bands it is readily elevated. In case there is slight bleeding it is controlled by very small pledgets of cotton guarded by long strings of silk to prevent their loss. As the tumor is free from the surrounding structures a septile snare is applied to its pedicle, which is gradually constructed to control the bleeding and to remove the tumor mass. The further removal of the pituitary tumor from the sella turcica may then be continued."

Transsphenoidal Methods.—*Supranasal Route.*—Schloffer first used this method. He turned the nose to the right, excised the turbinate, the ethmoid cells, and the septum, removed the inner wall of the left orbit down to the optic foramen and the inner wall of the antrum of Highmore with a portion of the nasal projection of the left superior maxilla, and then reached the tumor through the sphenoid sinus. Hochenegg, Moskowicz and Tandler, Chiari, Michel, Giordano, and others, have modified the procedure. Of all these modifications that of von Eiselsberg is most popular. His technic[1] is as follows:

[1] Described in Surgery, Gynecology and Obstetrics (International Abstracts, 1913, xvi, p. 245).

Three days before the operation the patient receives 2 gm. urotropin daily. The coagulability of the blood is determined and calcium lactate given if it is delayed. The nose and throat are carefully examined. Anesthesia with morphin and ether or Billroth's mixture. The operative field is sprayed with $\frac{1}{2}$ per cent. novocain (H. Braun), to stop hemorrhage. Tamponade is accomplished by Bellocque's method. The incision is made along the left nasolabial groove up to the glabella, over the bridge of the nose to the right palpebral fissure. The nasal bone is cut through with hammer and chisel. The philtrum nasi is cut at its juncture with the upper lip. A large portion of the septum and vomer is detached with the nasal flap. The remains of the septum, vomer, rostrum, and the turbinates are next removed.

Hemorrhage is stopped with adrenalin and compression. The sphenoid sinus is now opened, its anterior and inferior walls removed and the cavity scraped out. The hypophyseal tumor is usually exposed at this stage, the dura is incised, and as much of the tumor as is thought advisable is removed with a sharp spoon (excochleation). After stopping the hemorrhage a cigarette drain is placed in the defect and fastened by a stitch around the left nostril. No tamponade is necessary. Finally the nasal cavity is cleaned out, Bellocque's tampon is removed and the nasal flap sutured in its place.

Infranasal Route.—Owing to the danger of meningitis from exposing the cribriform plate and for the purpose of simplifying the procedure it was suggested by the author that the sphenoid should be approached through the inferior portion of the nose, thus avoiding the removal of the ethmoid. In his hands the operation has been most satisfactory. He has now modified the procedure as originally proposed in that a submucous resection of the septum is done, following the suggestion of Hirsch which is certainly a distinct advantage. Halstead and Cushing have since followed the same route with some modifications in technic. Instead of incising in the nasolateral fold, Halstead raises the lip and makes his incision in the labiobuccal fold. He has operated with brilliant success by this method. The author has used both the method to be described and the Elsberg method and believes that certain cases should be operated upon by the infranasal method and others by the transfrontal.

The infranasal technic has been described in the author's various contributions, from which this description is taken. Its steps are as follows:

The nose is packed with strips of adrenalin gauze to lessen the bleeding. The patient is placed in a semisitting position so that the blood will not accumulate in the sphenoid sinus and over the field of operation. A tight posterior nasal gauze plug is inserted. This is not necessary so much to prevent blood entering the pharynx since if the operation is done properly there should be no tear in the mucous membrane, but it does prevent air escaping through the nares during the operation. An incision of the skin down to the bone is now made in the crease close under the nares and the alæ of the nose. The nasal spine is cut and with the greatest of care the mucous membrane is raised from the floor of the nose and off of the septum, back to the sphenoid bone and off from the front of this bone. The septum and the anterior wall of the sphenoid sinus is now removed, followed by

FIG. 114.—Position of patient for hypophysis operation. (Author's method.)

removal of the posterior wall, *i. e.*, the anterior wall of the sella turcica. This is best entered by a chisel and the bone removed by a punch forceps. The dural covering now being cut the soft tumor mass appears and may be curetted away. If a cyst is found, its walls should be gently curetted and in my experience should be lightly packed with gauze saturated with a weak iodine solution to favor obliteration of the sac or to preserve an opening into the sphenoid. If a solid tumor is removed,

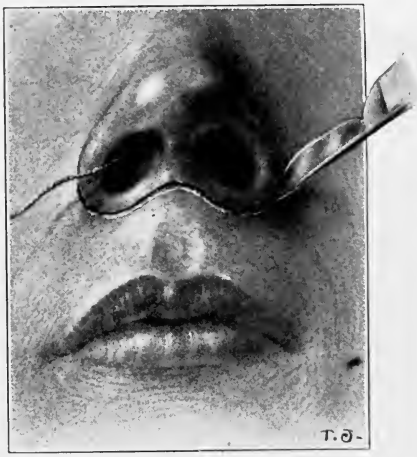


Fig. 115.—Line of incision for author's operation of hypophysectomy. A string is attached to posterior nasal plug.

no drainage is necessary if the bleeding is well controlled. The mucous walls of the removed septum are allowed to fall together, a subdermal

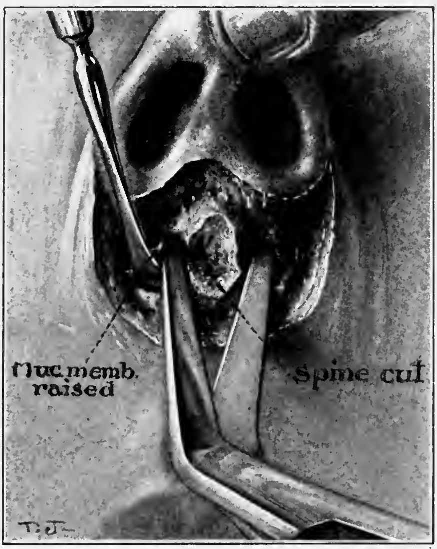


Fig. 116.—Hypophysectomy—author's operation. The mucous membrane is raised from the floor of the nose and the septum. The bony spine is being cut.

stitch closes the skin wound, the nares are packed lightly for twenty-four hours with bismuth subnitrate saturated gauze to stop the oozing of blood from the nose, the posterior nasal plug removed, and the patient returned to bed.

The anesthetic is best given through intratracheal insufflation, or pharyngeal tube, although the author has used rectal anesthesia with satisfaction. The operator should be familiar with the anatomy of the anterior of the nose, especially the sphenoid sinus, and the relations of the sella turcica. He should provide himself with proper instruments and an excellent headlight. No matter what method of approach is used, the operation is difficult and should be undertaken only after thorough preparation.

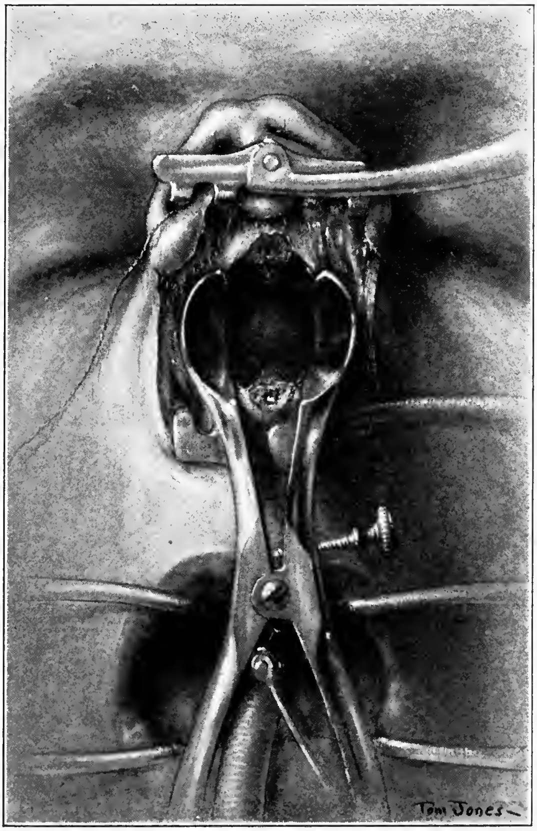


Fig. 117.—Hypophysectomy—author's operation. The mucous membrane has been pushed to the side by the speculum and the septum removed. The speculum is long and has a set-screw attached which holds it in position.

Hirsch has operated under local anesthesia with remarkable results. He has described his technic as follows:

In his earlier cases he removed the inferior and middle turbinates at the first sitting; at the second, the anterior and posterior ethmoids; at the third, the anterior wall of the sphenoid with the impinging septum; and at the fourth, the anterior wall of the sella turcica. The tumor was then removed by a curette. Later he suggested the submucous route, and urged it as a means of lessening the dangers of infection. He has described his technic as follows:

The mucous membrane of both sides of the nasal septum is desensitized with a 20 per cent. cocain solution. An incision is now made along the anterior edge of the quadrangular cartilage, through the mucous membrane on one side, down to the cartilage, and the mucous

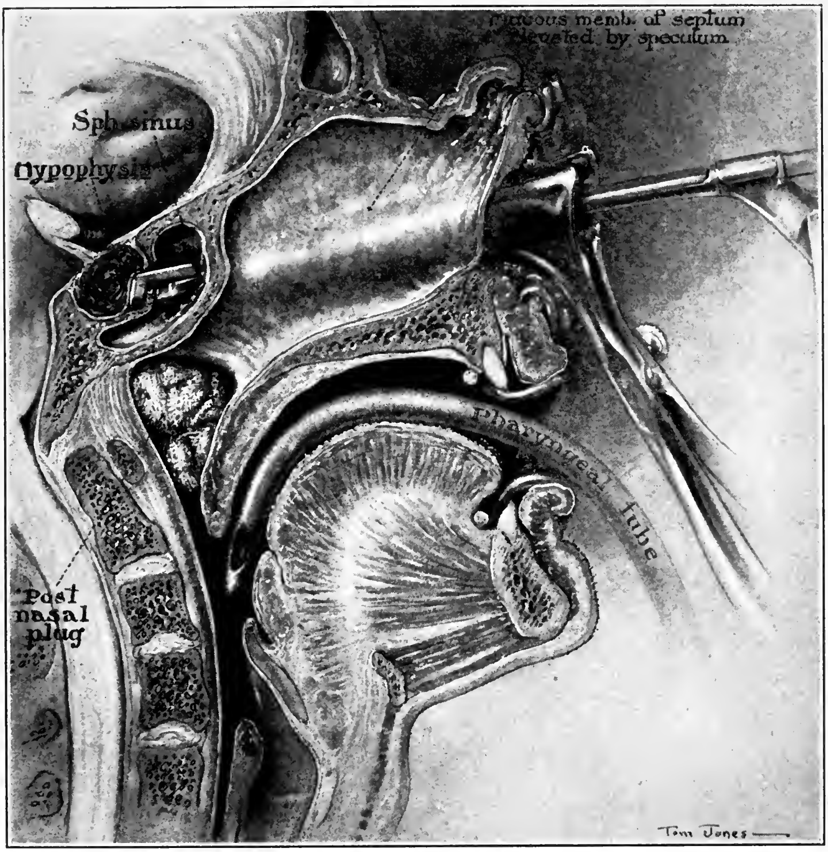


Fig. 118.—Hypophysectomy—author's operation.

membrane is raised by means of a raspatorium, together with perichondrium and periosteum, from the cartilage and bone. The cartilage is now incised $\frac{1}{2}$ cm. from the original incision and a raspatorium slipped between the perichondrium and the cartilage and carried to the posterior border of the septum; the mucous membrane, together with the perichondrium and periosteum, are now raised from cartilage and bone on this side. The membranes are now held apart by a nasal speculum and in this way a medial nasal cavity formed in which one sees the bare cartilage. This is removed with one sweep of the cartilage knife, and the vomer and the perpendicular plate of the ethmoid are resected with the aid of a bone forceps. Up to this point this operation is identical with Killian's submucous septum resection.

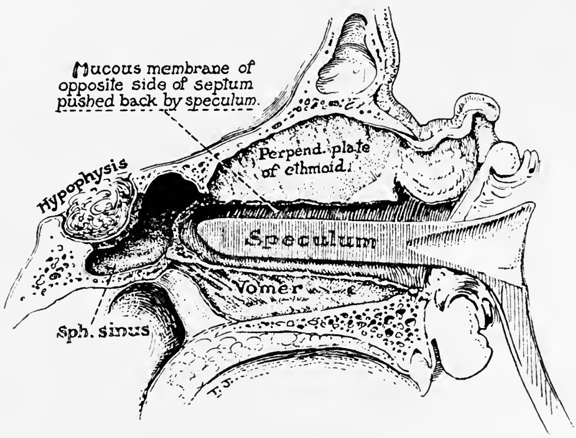


Fig. 119.—Hypophysectomy—author's operation. The mucous membrane which has been removed by the artist to show the line of removal of the septum, is preserved at the operation.

To bare the wall of the sphenoidal cavity it is necessary that the mucous membrane of the vomer where it joins the sphenoid be separated from the bone. This is very easily done, after which the mucous

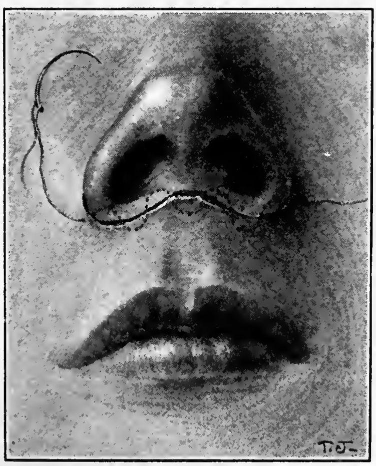


Fig. 120.—Shows the wound closed with subcutaneous stitch, no scar is visible.

membrane is separated from the anterior surface of the sphenoid on both sides as far as the ostium sphenoidale, so that the raspatorium falls into the sphenoidal cavity. Now through this sack of mucous membrane one removes the posterior part of the vomer and the rostrum sphenoidale, with the bone forceps, and with several strokes of a chisel one breaks through the anterior wall of the sphenoid cavity, and after removing the sphenoidal septum one sees the hypophyseal prominence in its entirety.

After opening the sella turcica and the dura of the hypophysis respectively, the hypophyseal tumor lies free in the sphenoidal cavity.

Approach Through the Mouth.—Many authors have suggested approach through the antrum of Highmore, or behind the soft palate, but they are not to be recommended.

Choice of Operation.—It is natural that in any procedure in which there are so many inherent difficulties and in which the outcome is not always satisfactory from the technical standpoint, there should be

Figs. 121 and 122.—Cyst of hypophysis. Note the enlargement of the sella and the eye-grounds shown in Fig. 123. This patient was operated upon three times by the author. The repeated operations were necessitated by the refilling of the cyst and each operation was done by the infranasal approach. Since the last operation, three years ago, he has remained well. The author has a second case with similar pathology, well after five years. (Wesley Memorial Hospital, 45762.)

considerable difference of opinion as to the advisability of various procedures, and also it is easily understood why the same surgeon may at different times be in favor of different types of operation. As our knowledge grows, it is certain that various modifications of procedures now suggested will be made. For the most part, however, adherence will be given, it would seem, either to an approach through the frontal area or infranasally. It would seem to the author that the various lines of procedure will be indicated ultimately by the type of pathology found in the various cases, and as our diagnostic acumen becomes developed we will be able to say that for one type of disease one method is better suited and for another type of disease another method of approach is better. It would seem that it is not advisable for any surgeon to become an adherent of any one method of procedure, but rather that he so equip himself that he is competent to approach hypophyseal tumors either through the nose or intracranially.

At the present time there is much to be said in favor of approaching all hypophyseal cysts by the infranasal route as described by the author. This type of disease we know to be most common in adipose types; Froelich's syndrome. The difficulty of removing all of the lining of the cyst and the probability of recurrence if the lining is not destroyed would speak in favor of an approach by which secondary

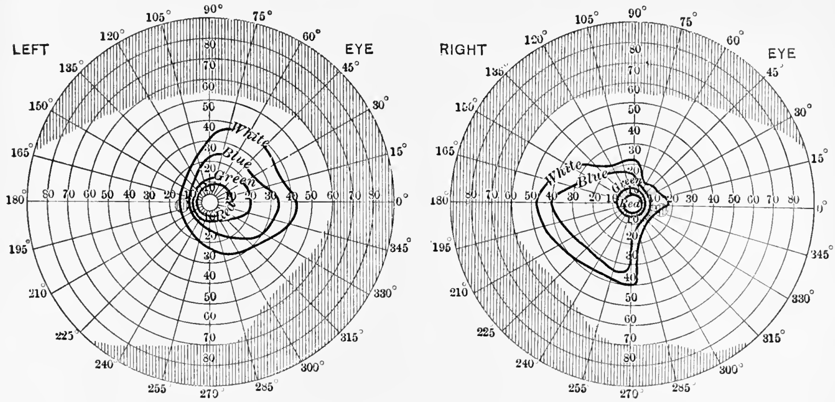


Fig. 123.—Before operation, see Fig. 122 (Case No. 45,762).

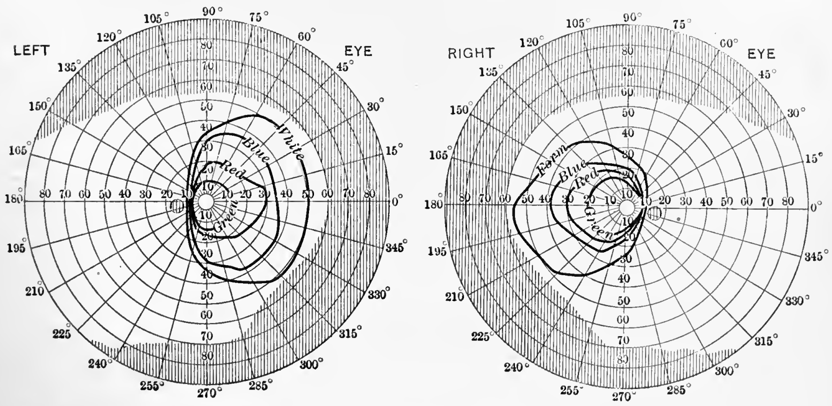


Fig. 124.—Eye-grounds in No. 45,762 (see Fig. 122) after the first operation.

operation could be done easily if desired. It is manifest that repeated intracranial operations would not be looked upon with favor since the difficulties would increase with each operation. Not only is approach through the nose in secondary operations feasible, but it is really much simpler in the primary procedure. The author has in one case operated three times upon such a cyst with complete primary recovery, judged by five years of freedom from recurrence. On the other hand, the field of vision is not so good through the infranasal approach as it is through widely executed frontal approach. Therefore, there is some justification for the belief that in many cases of adenoma the frontal approach is to be advised. Against this, however, is the fact that if the tumor is confined to the sella turcica it can be completely removed through the nose, probably with less trauma to the cranial tissues than if removed through the frontal route. This is especially true in those patients with an increased intracranial tension at the time of operation. The intracranial route is preferred, however, in a majority of solid tumors. In favor of the intracranial route, is the fact that neighborhood tumors may be reached at the same time when one has operated for an intracranial sellar tumor and it has not been found. The ability to remove such tumors with permanent recovery is yet to be proved.

FIG. 125.—*X*-ray picture of patient shown in Fig. 122, taken forty-eight hours after operation. The dark shadow is the outline of the cyst shown by the bismuth gauze which was packed in the cyst after opening. The packing was not done tightly; therefore, the cyst was probably much larger.

The transsphenoidal route gives a decompression opening in case of future growth. Thus it is possible to prolong life by it in those cases in which complete removal of growing tumors is not possible.

In general then it may be said that in those patients suffering from cystic disease, operation through the nose has many advantages and would seem to be the method of choice. In solid tumors an approach by the intracranial method, either that practised by Frazier and Elsberg or that advocated by Adson, would seem to be the method of choice. Future experience may modify these generalizations.

Indications for Operation.—It may be said that all cases of hypophyseal tumefaction should be operated upon, since even patients in extreme condition have been relieved temporarily. Operation is indicated absolutely in those patients in whom the tumor jeopardizes the life of the individual or is causing progressive blindness. It is relatively demanded for the well-being, when ultimately the life of the individual is threatened. Therefore pressure symptoms either local or general will demand immediate intervention. The pressure symptoms may be due to a rapidly growing tumor or to a cyst which may be enlarging rapidly or which has become suddenly filled with hemorrhagic extravasation. As our knowledge increases the field of relative demand for operation will be broadened. How far simple perversion of physiological action as evidenced by a lack of growth or overgrowth (acromegaly) should influence us in operation must at the present time be determined. As the safety of the procedure is increased and our knowledge of diagnosis progresses, it is to be hoped that the disease may be attacked before the destruction or perversion of these physiological actions may have occurred. Specifically we might say that the adiposegenital type of disease where an enlarged sella can be shown is by far the most favorable subject for operation. Acromegaly evidenced by increased secretion apparently must at the present time be treated conservatively, particularly since many of the cases at the time they are seen have passed through into the stage of hypopituitarism.

The mortality which in the past has been approximately 35 per cent. will probably so continue in the hands of those doing little cranial surgery. Cushing and Hirsch now report an average of 10 per cent. mortality, while the author has operated upon 15 cases with four deaths, all but one of these in the earlier cases. The patient has a right to an expression of opinion not alone as to the immediate result but also as to the ultimate result of any operative procedure. Our knowledge is yet so incomplete that we cannot give an absolute prognosis as to either. However, it would seem that we may assure the patient that good results as to local pressure can be assured in case of cysts. Horsley and others have shown evidence as to recurrence after operation and as stated above in one of the author's cases there were two recurrences after operation. But it would seem that repeated operations if necessary will ultimately end in a destruction of the cyst and that such cases may remain well is shown by the experience of various surgeons. The brain pressure is relieved, there is no further progress in the atrophy in the eye grounds, and the eye signs become uniformly improved unless complete nerve atrophy is present. The excessive adiposity has been lessened or removed, although this would seem to be aided by whole gland feeding. There has been little change in the sexual development, although von Eiselsberg reports some improvement in one of his cases. No marked change in growth has as yet been produced by operation or by gland feeding. The growth of hair seems to be improved, especially when gland feeding is instituted. The surgeon should bear in mind that hemorrhages may occur into the cyst giving rise to acute pressure symptoms, these pressure symptoms subsiding after the absorption of the blood. Therefore, an absolutely bad prognosis cannot be given even when operation is refused. It should also be borne in mind that many of the perversions of physiology are due not alone to the immediate pressure but to the previous destruction of gland tissue; therefore gland feeding should be instituted even though operation is not performed.

While some surgeons have reported an improvement following operation upon acromegaly, these results are so indefinite that one is inclined to be conservative regarding any physiological result which can be obtained by operation. There has been reduction in swelling of the soft parts with no effect upon bones. Hochenegg, von Eiselsberg, Cushing and others report the return of sexual function one year after operation which was supplemented by gland feeding. The sight when involved has been favorably affected. Cushing has stated that acromegalics who have gone over into a state of hypopituitarism have been markedly benefited by feeding the whole gland without operation. It is evident, however, that we are dealing with the ultimate stage of the disease, and it is to be hoped that the time may come when diagnosis may be made early and the operation be sufficiently safe to justify procedures in the early stage of the disease when it is probable more definite results may be obtained. Those intracellar adenomata can probably be removed with a possibility of no recurrence. Where they have grown beyond the sella, however, into surrounding area, it is problematical as to how much result will be obtained; although improvement of symptoms produced by local pressure and the amelioration of some general symptoms may be expected at least temporarily.

Pineal Gland Tumors.—Tumors of the pineal gland have been considered inoperable although attempts at removal have been made. While the operation should be considered a desperate undertaking, experience has shown that it may be feasible. Pussep made a horseshoe-shaped incision, the center of which was four fingers above the occipital protuberance, the ends curving down to the level of the mastoid processes and one and one-half fingers inside. The underlying bone was removed, and the wound closed. The second stage of the operation, six days later, consisted in ligating the occipital sinus and cutting the dura under the transverse sinuses. The right transverse sinus was ligated and cut. The dura along the longitudinal sinus upward and the tentorium inward, were cut. The occipital lobe being retracted, showed a cyst of the pineal gland. This was aspirated, some of the wall cut away, and the remainder packed and the wound closed. So much cerebrospinal fluid escaped on the first day that the packing was removed and the wound closed. The patient died on the third day, but lived long enough to demonstrate the feasibility of the procedure.

Rorschach has gone down beside the falx and cut the posterior portion of the corpus callosum. No tumor was found, but the only untoward result was a transitory paralysis of a leg and slight interference with sensation.

Nasetti has operated similarly except that he ligated the longitudinal sinus and cut the falx, then incising the corpus callosum.

Removal of Tumors of the Gasserian Ganglion is not exceptionally difficult. The method of attack is the same as for removal of the ganglion for trifacial neuralgia. The tumors are not common and are endotheliomata, arising from the dural sheath.

Puncture of the Brain and Ventricles.—Punctures of the Corpus Callosum.—This procedure carried out for diagnostic and therapeutic purposes is a measure of considerable value in some cases. It has been used most often in hydrocephalus, hypophyseal, cerebellar, and other

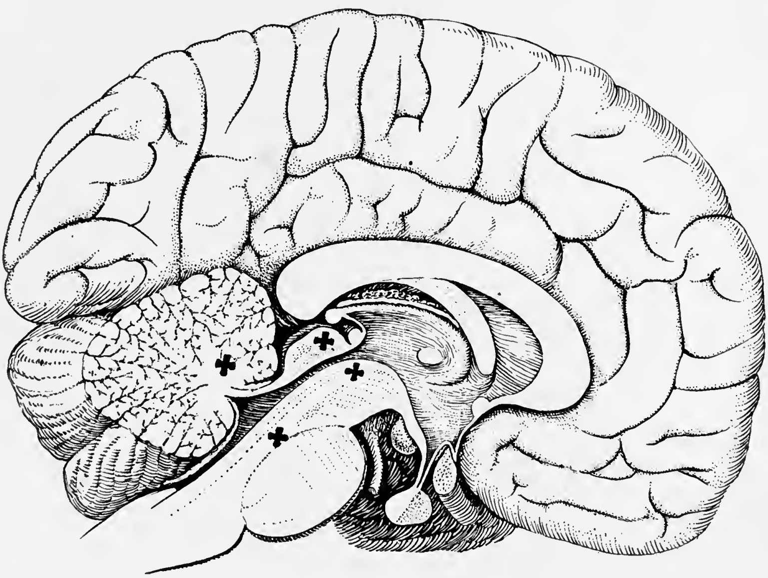


FIG. 126.—Schematic drawing representing a few of the areas in which tumors may especially produce hydrocephalus.

tumors which have caused large accumulations of fluid in the ventricles (Fig. 126). The principles upon which it is supposed to act is that if in cases where the pressure is high, an opening be made through the corpus callosum connecting the subarachnoid and ventricular spaces between the hemispheres, the intraventricular pressure will tend to keep the opening patent and thus provide a permanent drainage into a space where absorption of the secreted fluid is freer than in the ventricle. While the beneficial results in my hands have not been so brilliant as those reported by Anton and others, a moderate use of the procedure has convinced me that in certain cases we may expect great relief from pressure symptoms through puncture, and in a few cases a symptomatic cure. There is very little danger attached to the procedure. Veins may be injured leading to troublesome hemorrhages, or too deep puncture may injure the optic thalamus with temporary impairment. This is especially to be feared in basal tumors distorting the ventricle. No bad result has occurred in my experience except that in one patient there was a temporary paralysis of the arm; whether due to making the puncture too far back or to a change in pressure of the unlocalized tumor, was not known (Fig. 127).

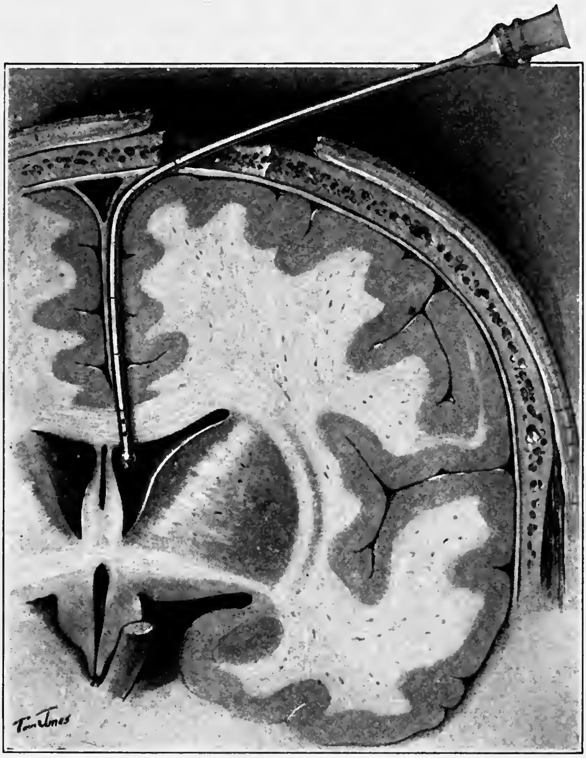


FIG. 127.—Technic of corpus callosum puncture.

Technic.—If the patient is not nervous the operation may be performed under local anesthesia. In such cases it is my custom to give, unless contra-indicated, a preliminary dose of scopolamine $\frac{1}{200}$ gr. and morphin $\frac{1}{8}$ gr. two hours and one hour before operation. The area being infiltrated, a longitudinal incision is made running backward from the coronal suture and parallel to the longitudinal suture. The skin and the aponeurosis of the occipitofrontalis are retracted by the ordinary mastoid retractor. A trephine now removes a button of bone the center of which is about 2 cm. from the coronal suture and the same distance from the longitudinal. A slit is made in a non-vascular part of the dura which is retracted with fine retractors. A puncture needle is chosen that has a blunt end. Elsberg uses a needle devised by himself in which the end is slightly bulbous with holes at the end and side. Before learning of this the author had devised a needle somewhat similar having, however, a more olive-pointed tip and the upper end flattened so the more perfect orientation at the concealed point is possible. The olive point enters the corpus easily but offers some resistance to withdrawal, thus indicating its position (see Fig. 128). The needle should be flexible, with a stylette, and should be at least 10 cm. long. The needle is bent at an angle of about 90°, approximately 6 cm. from the end, since this is the average distance from the surface of the brain to the ventricle. A few small veins pass from the cortex veins to the longitudinal sinus and in most cases there is a slight adhesion of the cortex to the longitudinal sinus. The needle is gently passed through this area and rotated downward along the falx cerebri. A slight resistance is felt when the corpus callosum is reached. The end of the needle is gently moved back and forth to avoid penetrating the pial vessels and then is thrust through the corpus and the stylette removed. If tension is present, the fluid flows out freely. The needle end is rotated back and forward for about a centimeter to tear the corpus callosum and then is withdrawn. Care should be taken not to

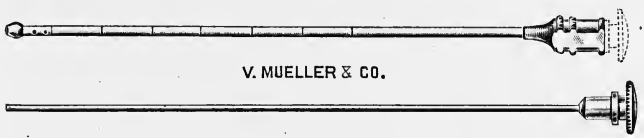


FIG. 128.—Modified needle used in corpus callosum puncture.

go too far forward and miss the ventricle and too far backward and do injury to important structures. The dura is closed, the bone plug replaced or not as desired, and the wound closed.

Puncture of the Ventricles.—If the third ventricle be dilated it may be reached through the corpus callosum puncture just described; if not, the puncture will reach a lateral ventricle. Other sites for puncture of the lateral ventricles may be chosen and in ordinary cases where we wish to aspirate them for diagnosis or for therapeutic purposes, these locations are preferable. The relation of the ventricles may be seen from examining Plate IV. It should be remembered that the ventricle lies nearer the median line than the beginner would believe. The known centers should be avoided and care used not to injure pial vessels or to direct the needle toward the choroid plexus or the island of Reil where hemorrhage is very likely to occur. Again, the needle should be thrust directly into the ventricle and not moved about after the puncture is started. In the hands of the expert operator, puncture may be made from almost any site. Kocher, Keen, Neisser and Pollock, and others have drawn attention to points of election. Kocher's point is $2\frac{1}{2}$ cm. from the median line and 3 cm. anterior to the central fissure. The ventricle lies at a depth of 4 to 5 cm. and the widest part, 2 cm. in width, is somewhat backward. Keen's point is about 3 cm.

behind and 3 cm. above the external auditory meatus. The needle is carried in about 5 cm. in the direction of the opposite pinna. This strikes the ventricle where the lateral and posterior cornua are given off from the body of the ventricle at the posterior end of the thalamus.

The puncture can be made under morphin $\frac{1}{4}$ and scopolamine $\frac{1}{100}$ in divided doses, with local anesthesia for the scalp and even without the latter if a rapidly moving hand power small drill 2 to 4 mm. in diameter is used to go through the scalp and skull. If a craniotomy has been done one remembers that Keen's point corresponds to the posterior part of the first temporal convolution. If the frontal lobes are exposed, the anterior cornu is reached best through the second frontal gyrus about $1\frac{1}{2}$ cm. from the median line. In children the ventricle may be reached by puncture through the lateral angle of the anterior fontanelle, the needle being directed slightly backward and downward.

Puncture of the Brain Substances.—The first systematic description of brain puncture was given by Schmidt, but Neisser and Pollock have given us the most comprehensive clinical article upon the subject. They have located the points of predilection for diagnostic puncture and demonstrated that it can be done without great danger to the patient. On the other hand, there is a real possibility of injury to the pial vessels and sinuses; therefore, blind puncture should be resorted to only in exceptional cases. It is far better to remove a button of bone and thus avoid any possibility of injuring the vessels or sinuses. The procedure is carried out by means of a medium-sized needle with a stylette. Neisser uses a graduated platinum-iridium needle, 7 cm. long and 1.06 mm. thick, with an oblique point. The needle is inserted 3 to 4 cm. The stylette is withdrawn and, if fluid or pus is present, it can be determined readily. If search is being made for a solid tumor, aspiration is now done and the small particles drawn into the needle examined microscopically. It is evident that in the latter instance the results obtained are far from satisfactory. The educated finger may, however, obtain data of value as to density of the tissue penetrated and in case of cyst, abscess, or hydrocephalus, real knowledge may be secured. Neisser and Pollock's article[1] illustrates the points of election.

CEPHALOCELE.

Diagnosis.—The diagnosis of cephalocele rests upon the congenital nature of the condition, the location of the tumor in the lines of fetal closure of the skull, and the physical characteristics. While cephalocele may grow large after birth they are always congenital, and are to be found especially in the median line in the occipital or lower frontal region, the latter being most common. They may appear at the base between the ethmoid and sphenoid projecting into the nasal cavity, where they may be mistaken for polyps. Such a case is reported by

[1] Die Hirnpunktion, Mitt. a. d. Grenzgeb. a. d. Med. u. Chir., xiii, 807.

Christian Fenger, in which an error in diagnosis led to operation and death. Cephalocele occurring in the occipital region may emerge above or below the occipital protuberance, communicating in the former instance with the posterior fontanelle and in the latter with the foramen magnum. Those which appear in front emerge through the horizontal plate of the ethmoid and appear above or below the nasal bones, the former being most common.

On examination cephalocele may be translucent or opaque, varying with the contents of the sac which may be made up almost entirely of cerebrospinal fluid or, in rare instances, brain tissue alone. The character of the sac and the contents gives the name to the various types: meningocele, or better hydrencephalocele; myelocystocele; kenencephalocele (Heinecke); myelocystomeningocele; encephalocystomeningocele. Histological examination of the sac wall shows skin, subcutaneous tissue, arachnoid membrane, either cystic or non-cystic, and a layer of tissue which may be either the ependymal lining alone of the ventricle or a thin or thick layer of brain tissue lined with this ependyma. In other words, the interior of the tumor is continuous with a ventricle; the pericranium, skull, and dura being absent. The pericranium and dura generally merge into each other at the base of the tumor. If the tumor contains only the ependymal lining it is called a hydrencephalocele; if some brain tissue be present with considerable fluid, it is a myelocystocele; if the arachnoid be the seat of cystic degeneration, it may be either a myelocystomeningocele or an encephalocystomeningocele. It will be seen, therefore, that pure meningocele is extremely uncommon as first shown by Muscatello. The opening into the ventricle proper may be very small.

The tumors may be of any shape from flat to pedunculated; the skin may be loose or tense; they may or may not be translucent, solid, or fluctuating; they may or may not pulsate. Attempts to expel the contents of the sac into the brain cavity should not be made since the increase of brain pressure may give rise to alarming symptoms; but lumbar or tumor puncture to study the content or, in the former instance, the decrease of tension, is justifiable. Dermoids may occur at these sites and are differentiated by the physical characteristics and the result of puncture.

Treatment.—Cases of encephalocele with exencephalus live only a short time and hence are inoperable. The same may be said for those cases complicated with hydrocephalus or severe congenital lesions destroying the brain, or those arising from deep portions of the brain involving vital structures such as the medulla or the basal ganglia. Where there is a fairly well developed head, however, with the cephalocele engrafted upon it, operation is frequently followed by good results, the results being in inverse ratio to the amount of brain tissue in the sac. The presence of some brain tissue does not necessarily preclude operation since the function of the portion of the frontal lobes destroyed may be taken over by that remaining. The cases with small pedicles and little brain tissue give especially good results.

The tumor should be removed at the base, making no attempt to replace any brain tissue. A considerable amount of cerebrospinal fluid may be lost without endangering the life of the patient, but provision should be made to prevent such loss by placing the patient in such a position during the operation as to prevent the escape of the fluid. The lining membrane should be sutured together, the neck of the sac isolated from the surrounding bone, and the edges brought together if possible. If this is not possible or if the union is seen to be weak, a layer of fascia lata should be transplanted to cover the defect and carefully sutured to the outer surface of the surrounding dura allowing the edges to lie under the bone. If possible a flap of bone from the adjacent region should be transplanted to cover the defect. This latter is often not feasible and frequently not necessary. Because of the age and general condition of these patients, osteoplastic and complicated operations are not generally indicated.

HYDROCEPHALUS.

Diagnosis.—The diagnosis of the presence of hydrocephalus is made easy by the well-known characteristics presented by the condition. The skull is large with a flaring vertex, overhanging the facial bones; if young, the fontanelles are not closed and the sutures may not be united, and through the thinned skin the veins engorged by the

Fig. 129.—Hydrocephalus.

increased intracranial tension show plainly (Fig. 129). As the disease progresses, destruction of brain tissue and pressure upon the tracts leads to mental deterioration, rigidities of the muscles, with spasms, etc. If the condition comes on later in life the hardening of the bones may preclude the marked changes to be seen externally, but within the process may be more intense. External hydrocephalus is uncommon, although we may have a spurious external hydrocephalus due to serous meningitis, cystic change in the arachnoid, and the local degeneration of brain tissue with fluid formation and perforation into the subdural space, such as may occur in cerebral hemorrhage in the newborn.

Internal hydrocephalus is the more common. For the purposes of treatment a diagnosis should be made as to the location of the obstruction if one is present, since it is very important to know whether the serum passes freely into the fourth ventricle and the spinal subarachnoid space. Obstruction is most often seen at the foramina of Monro or Majendie or along the iter. In the true form this closure is probably due to inflammation but it may be seen as a result of tumor formation pressing upon the walls and thus obstructing the exit of the serum (Fig. 130). In many cases on examination no obstruction can be found.

Fig. 130.—Internal hydrocephalus, probably inflammatory, but possibly due to hypophyseal cyst. Following subtemporal decompression during the acute stage papillitis disappeared and the patient has had no symptoms for six years. Note the decompression tumefaction upon the right side.

Treatment.—For the purpose of treatment, the surgeon should determine if possible if obstruction is present. In those cases in which lumbar puncture fails to relieve the excessive cranial pressure, we assume such obstruction to be present and direct our surgical procedures to the cranium. If no obstruction is found, either lumbar or cranial drainage may be instituted.

Unfortunately no procedure has been found to be of great avail in this condition. Failure has been due chiefly to two causes: (1) the altered condition of the brain at the time the patient is presented for treatment (Fig. 131), and (2) the inability of the surgeon to produce continuous drainage owing to connective-tissue growth about the size of the drainage tube. To correct the first, all physicians should be urged to present the cases for as early operation as possible. Various procedures have been suggested to overcome the second difficulty. Unfortunately, none are particularly satisfactory. Direct puncture of the ventricles through either Keen's or Kocher's point (*vide supra*), followed by the insertion of tubes of various material such as glass, silver, etc., has often been tried with isolated successes. These tubes may reach to the subdural space or into the subcutaneous tissue. In either case, scar-tissue is likely to interfere soon. To obviate this, Payr suggested transplanting living veins, either in continuity with the vascular system or into the subdural space. The author has had some experience with this procedure. Temporarily the cases were relieved, but ultimately they ceased to drain. Others have made living tubes

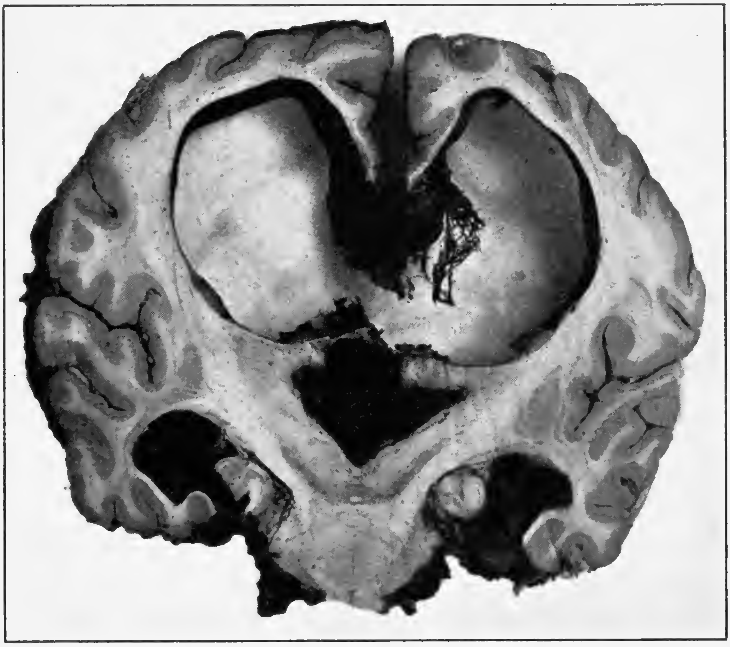


Fig. 131.—Moderate degree of hydrocephalus showing brain change.

of dura, with probably no better success. Murphy suggested drainage of the fourth ventricle by opening through the roof, and lately Haynes has tried to insert a silver tube from the fourth ventricle to the lateral sinus. Haynes makes an incision from the occipital protuberance to the foramen magnum, somewhat to one side. The bone is removed up to and over the sinus. A purse-string suture holds one end of a specially prepared angular tube in the roof of the ventricle and the opposite end in the sinus. Owing to especially favorable conditions any of these procedures may at times be successful, but for the most part they are doomed to failure. Anton has reported several cases treated by corpus callosum puncture (*vide supra*) with marked relief, and to this the author can add his experience. While it is often not satisfactory, in several cases, both of acquired hydrocephalus due to tumor and other conditions, and in the infantile type, the results have been all that could be expected.

In those cases in which communication is free into the subarachnoid. spinal space, drainage may be instituted in the lumbar region, either anteriorly or posteriorly. The technic here also has the same disadvantage as that instituted on the cranium. Metal tubes, silk, veins, arteries, etc., have all been used. Cushing suggests doing a laparotomy, splitting the peritoneum to the left of the rectum, trephining the fifth lumbar vertebra, and inserting the female half of a silver cannula down to the spinal dura. The child is now turned over and a laminectomy done, the subarachnoid space opened, strands of cauda separated, and the male portion of the cannula locked in the female. The wounds are closed and the fluid escapes into the retroperitoneal tissue, unless connective tissue obliterates the opening. The same procedure may be carried out by using the patient's saphenous vein. The vein is sutured in place, fat being left on the vein to prevent collapse. In a majority of cases any of these procedures end in failure. At times in acute hydrocephalus, repeated lumbar puncture may apparently produce a cure.

HERNIA CEREBRI.

Treatment.—This lamentable condition generally presupposes one or both of two conditions; increased intracranial pressure, and infection. The treatment is based upon the removal or lessening of the protrusion and procedures designed to retain the structure. As a preliminary the intracranial tension should be lowered and this is best done by lumbar puncture, frequently repeated. If the tension is intracranial, ventricular puncture may be indicated. If this is not sufficient, the protruding mass may be removed, especially if it comprises a "silent" area. The pericranial tissue may now be sutured over the area with tension sutures, and in favorable cases a flap of fascia lata may be inserted although infection which is commonly present may preclude this procedure or vitiate the result. Osteoplastic flaps after the Koenig method may be used. Where the tension is not too great, or where the opening is small or the protruding brain tissue sloughs off, granulation-tissue will spring up and the wound heal by cicatrization or be covered by Thiersch grafts.

TURMSCHÄDEL AND OXYCEPHALIA.

This condition has been supposed to be due to a congenital or premature closure of the fissures in the skull (Fig. 132). If the fissures at the base and the sides are closed thus early, there is a tendency for the skull to grow upward presenting the appearance shown in the photograph. This naturally leads to an increase of intracranial pressure as evidenced by intense headache, the early development of optic atrophy and proptosis of the eyeball. The condition is one not readily amenable to surgical intervention. Discovered early, however, an extensive decompression operation may be done. To prevent the secondary changes in the eye due to turmschädel, Schloffer has advocated in certain cases removing the roof of the orbit and that section of the bone through which the optic nerve escapes from the skull.

FIG. 132.—Turmschädel.

INFLAMMATIONS OF THE BRAIN AND THE MENINGES.

Pachymeningitis Externa.—This condition associated with coincident osteomyelitis, syphilis of the bone, erysipelas, tumors, etc., should not be considered as a special disease. Since the process is localized, the signs are those of the causative disease with some evidences of subjacent brain irritation or pressure. These latter are slight as a rule. Prompt removal of the cause with adequate drainage will generally relieve the condition. In the acute inflammatory disease, *e. g.*, otitis media, unless prompt treatment is instituted it may lead to an acute leptomeningitis.

Pachymeningitis Interna Hemorrhagica.—Whether this condition is due to an inflammation as maintained by Virchow, Hesche, and Barrat, or to a hemorrhage followed by organization (Spiller, McCarthy) is open to question. Pathologically early we see a delicate pink or grayish deposit on the inner surface of the dura. This deposit is detachable and is usually studded with punctiform hemorrhages. The dura may be slightly distended. Successive layers are at times deposited, making a thick membrane. Oppenheim says that the milder grades of the disease may accompany any chronic inflammation and that it is common in senile dementia, chorea, any general infection, hemorrhagic disease, alcoholism or injuries.

Diagnosis.—A probable diagnosis may be made in the presence of one of these etiological factors accompanied by the evidences of cortical irritation and followed by the evidences of pressure, but lacking the signs of acute meningitis with its cranial nerve involvement and spinal fluid changes. At times the diagnosis may be confirmed by finding blood mixed with the fluid. The picture may be atypical and acute or subacute.

Treatment.—In a majority of cases the treatment will consist in sedatives, and the local use of an ice cap, combined with elimination by cathartics. Neisser and Pollock have reported cures by their method of brain puncture, but the operation surely should be done only in exceptional cases or not at all since the danger of injury to the pial vessels is too great to be overlooked. In severe states of pressure or prolonged convulsions, a decompression operation is indicated. Repeated lumbar puncture gives a slight measure of temporary relief, and in mild cases may be of benefit.

The treatment of post-traumatic extravasations and allied conditions leading to mental changes as well as the acuter more extensive meningeal hemorrhages, will be discussed in the section devoted to traumatisms.

Acute Inflammation of the Meninges.—We shall limit our discussion to those types of meningitis of especial interest to the surgeon and speak here of the generalized form, reserving for the section upon abscess and localized inflammations the discussion of pachymeningitis and serous meningitis.

The acute inflammation may arise in the course of any of the acute systemic diseases, such as pneumonia, influenza, etc., or may be due to the introduction of bacteria through traumatic sources or by extension from a local suppurative process in the bones, sinuses, or bloodvessels, adjacent to the brain. It is manifest, therefore, that the onset may be fulminating, or more or less chronic if the organism be avirulent, or the local condition present the possibility of plastic exudate, hindering the rapid spread as in chronic otitis media. In the more explosive form there may be no prodromal symptoms. In the chronic type the prodromal symptoms may precede the typical signs of meningitis by many days, consisting of malaise, slight headache, etc., characterized by the patient as bilious symptoms. The typical symptoms of extending leptomeningitis may be characterized as toxic, irritative, and paralytic, and the diagnosis is made upon these added to the history of an etiological factor, the findings upon lumbar puncture and physical examination. Unfortunately for the standpoint of surgical relief, we have no pathognomonic early symptoms. Haines has emphasized the rapid increase of blood-pressure and edema of the fundus.

The patient complains of an intractable headache incompletely relieved by morphin. Exacerbations are noted even during delirium; some optic neuritis is present but not the typical choked disk; vomiting is frequent but not constant. The patient rapidly passes into delirium, convulsions, and finally coma. Meanwhile, the fever may be most variable, being high or even subnormal later. The pulse may be fast or slow. The urine is febrile and may contain sugar. In addition to the signs of cerebral tension and irritation, the signs of nerve irritation become marked. The vision may become dim and photophobia appear. The eye muscles may become spastic or paralyzed, the pupils contracted early and later dilated; the seventh nerve may produce muscular twitchings in the face. Irritation of the sensory nerves produces hyperesthesia of the skin and irritability of the muscles; of the motor nerves, stiffness of the neck, abdominal rigidity, inability to extend the leg (Kernig) or flex the thigh (Lasègue), or convulsive seizures, etc.; of the trophic nerves, herpes, urticaria, and other skin eruptions of the vasomotor nerves, secretory and vasomotor phenomena.

Early lumbar puncture will show little, but later turbidity produced by polymorphonuclear leukocytes and few or many bacteria will be present—a finding which should not be awaited if we expect to benefit the patient by surgical treatment.

The symptoms of acute meningitis may be produced in a modified form by local infective processes in the cranial cavity and also by the toxemias of acute infections; *e. g.*, pneumonia, typhoid, septicemia, uremia, delirium tremens, hysteria, etc. In children even gastrointestinal disorders may present a typical picture, except for the physical findings, the cerebrospinal fluid changes, and the rapid recovery following catharsis. It should be noted that acute otitis media especially in children may give headache, convulsions, delirium, stupor, and even a paralysis of the sixth nerve from accompanying edema.

Treatment.—Owing to the fact that little can be expected from treatment, especial care should be used in prophylaxis. This consists in asepsis in cranial injuries and treating otitis media and various chronic sinus infections. Some clinicians believe, in spite of experimental evidence to the contrary, that the administration of large doses of hexamethylamin (gr. xxx to xxxv) every few hours may retard infection, and the author has used, with apparent success, antistreptococcus sera in 50 c.c. doses as a prophylactic in certain operative procedures where there was great danger of such infection.

When the infection has once started, the primary focus should be treated and free local drainage instituted. Beyond this many procedures have been suggested without as yet demonstrating any positive benefit in severe cases. Many milder types have apparently been cured by repeated lumbar puncture.

Various operative procedures having for their purpose drainage or the introduction of medicaments have been suggested. The condition of the patient is not impaired by these and a certain few cases have apparently been benefited. The repeated intraspinal injection of hexamethylamin (McKernon) gr. 100 in sterile solution in such concentration as that its bulk equals one-half of the amount of cerebrospinal fluid removed has been followed by a few recoveries. Others (Barr) have introduced a needle into the ventricles and injected sterile normal salt or antiseptic solutions, meanwhile removing fluid by lumbar puncture; this has not as yet given satisfactory results but is worthy of further study. Haynes has suggested drainage by way of the cisterna magna. An incision is made downward from the occipital protuberance, and the tissues retracted, a trephine opening is made one inch below the protuberance and enlarged by the rongeur down to the foramen magnum. The dura and arachnoid are opened and a gutta-percha drain inserted. Day and others, however, have not had success with this procedure.

Barth has reported the recovery of three cases in which lumbar drainage by laminectomy was performed and Leighton has since reported two recoveries by the same procedure. An incision is made over the third lumbar vertebra and the spines and laminæ of the third and fourth removed. The dura is opened and a drain inserted down to the dura and the muscles sutured. During its operation the head is placed at a lower level than the wound.

Early diagnosis and treatment is undoubtedly a strong factor in the cure and at the present time a thorough eradication of the focus of infection with free local drainage added to lumbar drainage would seem to offer the best results, and it is possible that to this may be added intraspinal urotropin injections.

Brain Abscess.—Diagnosis.—Abscess of the brain appears in one of three forms: (*a*) acute fulminating; (*b*) latent; (*c*) stage of exacerbation.

(*a*) The *acute fulminating type* is an immediate sequela of a primary focus still present, and besides the focal and general evidences of brain lesion presents to a marked degree the signs of the primary focus and the evidences of inflammation, *e. g.*, fever, leukocytosis, etc. Here the question is not the diagnosis between an abscess and a tumor, but rather the diagnosis from an extradural or intradural abscess, meningitis, both purulent and serous, and the primary focus itself. This is often most difficult and frequently can be told only upon operation.

The extradural abscess does not present the marked focal evidences frequently present in the abscess. If it develops from an otitis media, there is often pain on pressure back of the mastoid, swelling in this region, and a tendency to hold the head in a fixed position, and upon operation such an amount of pus is evacuated before reaching the brain that the operator concludes that the pressure may have come from this.

In purulent meningitis we have the presence of bacteria and leukocytes in the spinal fluid. The evidences of a more diffuse involvement of the entire system is described above.

Sinus thrombosis is considered below.

Subdural abscess, purulent meningo-encephalitis, is to all intents and purposes, a brain abscess.

Serous meningitis frequently accompanies an otitis media. Here we have a diffuse involvement with an early optic neuritis. The symptoms are relatively mild, as regards temperature. The focal symptoms are generally less positive and persistent than in abscess and less extensive and severe than in purulent meningitis. It should be remembered that any of these processes may accompany an abscess.

(*b*) *Latent Stage.*—An abscess may remain for many years and produce no signs whatever, or there may be a history of vague symptoms, particularly slight headache, some impairment of vision especially upon careful tests, and mental deterioration, noted especially as hebetude (Fig. 133).

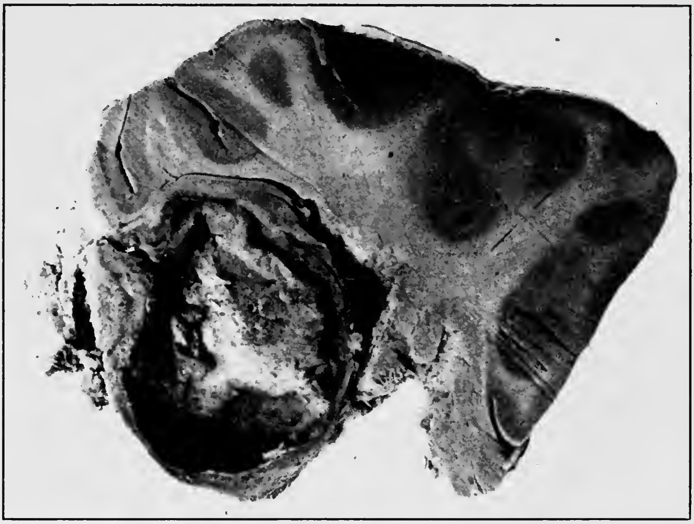


Fig. 133.—Old abscess of the brain.

(*c*) *Stage of Exacerbation.*—This may appear in various forms from indefinite evidences to positive signs of brain involvement as noted below. Here the question of diagnosis from brain tumor immediately arises and we search for a history of a primary focus and the evidences of inflammation, either of which will be of great aid in the diagnosis. Unfortunately the primary focus may have healed years before, while the encapsulation and a toxicity of the old abscess may prevent the development of the evidences of inflammation.

The stage of exacerbation is prone to be ushered in brusquely in one of the following ways: The patient may begin suddenly to complain of headache and vomiting. The patient seems to be somewhat apathetic, and an examination of the eye grounds often shows a retinitis, whether due to pressure or to toxemia as Lewandowsky suggests, may be open to question, but the frequent absence of choked disk seems to speak for the latter. Slow pulse is frequently present. In addition we may have focal symptoms from the sites of predilection of abscess.

The occurrence at any time of life of a hemiplegia which starts as a monoplegia and requires several days for development, if accompanied by the above symptoms and particularly if signs of inflammation are present, is very suggestive.

The sudden onset of convulsions, otherwise unexplainable and accompanied by fever, very strongly suggests abscess. The more or less sudden development of aphasia or monoplegia in a patient with a history of otitis warrants in a majority of cases the diagnosis of an abscess.

Given any one of the groups of symptoms, the diagnostician immediately searches for confirmatory evidences as found in (*a*) sign of inflammation, (*b*) primary focus, (*c*) focal signs.

As has been said fever and leukocytosis may be absent in fully a third of the cases, and when present they are generally moderate in degree. A high fever generally indicates either acuteness, impingement of the abscess upon the meninges or ventricles, or rupture into them. Chills may be present.

The most common source of abscess is the middle ear, but the abscess may arise from a nasal sinus or from orbit disease, from any other focus about the skull, or from a metastatic source. The nasal sinus or orbit naturally give rise to frontal abscesses, the roof of the tympanic cavity or of the mastoid to temporal, and the mastoid process and labyrinth to cerebellar abscesses. Metastatic abscesses locate along the Sylvian fissure.

Focal symptoms may be entirely lacking, especially in the frontal and right temporal lobes. The left temporal may give rise to partial or complete word deafness, amnesia, or paraphasia. If the abscesses are large or deep, they press on the motor and sensory zones with corresponding signs. When arising from the ear, they frequently lie near the base and may give rise to basal nerve signs, especially the third and sixth.

For a complete discussion of focal signs in the various regions, the reader is referred to that section in the early portion of the chapter, since they differ in nowise from those found in tumors.

Treatment.—Since about a third of the abscesses of the brain follow infected injuries and a considerable proportion of the remainder have their origin in otitis media especially of the chronic type, especial prophylactic care should be directed to these conditions.

When there is no evidence of a primary focus and no localizing signs can be elicited, we should remember that by far the largest number of abscesses are found in either the temporosphenoidal lobes or the cerebellum. They may, however, be found in the frontal lobe from nasal or orbital disease, along the Sylvian fissure, from metastatic foci, the occipital lobe, or, indeed, any part of the brain. Statistics would seem to show that 60 per cent. of the abscesses are in the temporosphenoidal lobe, 25 per cent. in the cerebellum, and 15 per cent. in the frontal lobe and other parts of the cerebrum. Ballance has suggested that in suspected abscesses with nothing to suggest a location, we should make a good-sized decompression, open the dura by the flap method, and pack the area under the edges of the dura for one or two days for the purpose of producing limiting adhesions and favoring the advance of the abscess toward the surface—a procedure that has much to recommend it in certain cases. In whatever portion of the brain we attack we should remember that the abscesses tend to lie in the white matter, owing to the fact that it is more easily liquified than the neuroglia-bound cortex upon which the abscess is prone to impinge, however, and hence seldom lies deeper than an inch. Again, the abscesses tend to lie in juxtaposition to the site of origin. Thus frontal abscesses most frequently lie in the inferior frontal convolution; the temporosphenoidal in the inferior convolution near the petrous portion of the temporal bone; the cerebellar in the lateral lobe near the same bone; while the metastatic lie near the Sylvian fissure. Ballance has drawn attention to the so-called "stalk," a connective tissue sinus-like connection between the abscess and the site of entry. When this is found it is a valuable guide in locating the abscess. Owing to the fact, however, that most unlocalized abscesses are approached from the external surface and these "stalks" come off from the petrous portion of the bone on the basal portion, they are not frequently found at operation, except by the otologist who searches for the abscess by way of the ear. Much controversy is found as to the proper technic to be used in searching for the abscess. Lately Sharpe has advised large osteoplastic flaps over the temporal or cerebellar regions, not alone for more adequate investigation, but also to guard against the ill effects of consequent brain edema. If Sharpe's method is followed a muscle-splitting operation should be done to prevent hernia, since if the abscess is found, drainage must be instituted. It probably is true, at least, that the small trephine openings advocated by some are frequently inadequate. Again, there is much debate as to whether the dura should be cut in flap form, the subdural space walled-off, and the abscess sought for at the time or after a day or two, or whether multiple small cuts should be made through the dura and the punctures made through these. The latter has much to recommend it in cases where there is considerable doubt as to the diagnosis. Puncture through the unopened dura should never be done owing to the possibility of injury to the pial vessels.

The pus is generally thick; therefore, if a needle is used it should have a 2 mm. aperture at least. Ballance and others recommend a knife, but most surgeons prefer a large needle, groove director, or preferably a searcher of small size that has two blades which may be separated, allowing the pus to escape between the blades. Page and others have devised and described such forceps (Fig. 134). Having found the abscess, the pus should be allowed to escape freely. Krause inserts his finger and breaks up the loculi, a procedure that in most cases is not advisable, but if it were done would probably lead to detection of secondary abscess if they were present. It goes without saying that the subdural space should be well walled-off by gauze if limiting adhesions are not present. Gutta percha or cigarette drains should be inserted, and in the chronic cases should be left in for a considerable period. One case coming under the author's observation was drained three times with ultimate recovery, a multiplicity of operations which would have been avoided if the drain had been left in place longer—a procedure which necessitates suturing the drain to the skin or dura.

With these general principles considered, let us ask ourselves what should be our method of attack in a given case. While considerable difference of opinion exists as to the proper procedure, it has seemed to the author that the following may be considered as a working basis.

1. *In chronic cases with no localizing signs* or evidences of primary focus, a large subtemporal muscle-splitting decompression with cutting of the dura may be done, and the undersurface of the dural edge traumatized or packed lightly with gauze to produce adhesions after the Ballance method. The opening should be adequate and go well down on the temporal bone so as to expose the first temporal convolution. Its greatest diameter should be anteroposterior to give ample field for puncture in various directions. The frontal or cerebellar regions may be similarly exposed when desired.

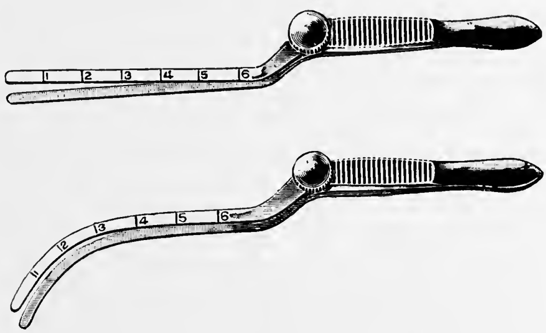


Fig. 134.—Page pus searcher.

2. *Acute Processes with Suspected Abscess.*—Let us suppose the process to be an acute otitis media. As stated above the diagnosis is difficult and we may be in doubt as to whether we are dealing with an otitis alone or otitis complicated with an extradural abscess, a sinus thrombosis, serous meningitis, subdural abscess, or an intracerebral or intracerebellar abscess. The condition of the patient in any case will be such as to demand expeditious operation. Therefore, our operation should be so planned as to meet these possibilities. We have three courses open: (1) we may begin with the ear, open the mastoid, antrum, and ear, and then proceed directly to the cerebrum or cerebellum as the diseased bone may suggest; (2) after opening the mastoid we may make a second trephine opening over either the temporosphenoidal lobe or the cerebellum; (3) after opening the mastoid we may make the opening over the sigmoid sinus and enlarge the opening both upward to expose the temporosphenoidal lobe and downward and backward to expose the cerebellum. In a majority of the acute cases, it is wiser to proceed directly from the ear, in which case the technic is as follows: The mastoid and ear having been cleaned out rapidly without attention to minor details, the wall is examined for caries. If

the wall of the tegmen or the anterior surface of the petrous bone are destroyed, it suggests extradural abscess here or temporosphenoidal abscess; if over the vestibule or the internal auditory meatus the cerebellum is suspected or both, they may be examined if desired. If the posterior fossa is suspected the bone is removed over the sinus; if extradural, pus is evacuated. This may be all that is necessary. The sinus is palpated and inspected. If still unsatisfied, two routes are available; viz., to the inner or outer side of the sinus. Infection from the antrum may produce a lateral sinus thrombosis, or pass internal through the dura mater. Infection from the labyrinth may pass between the semicircular canals and destroy the posterior wall of the petrous portion or may pass into the internal auditory meatus and along the seventh or eighth nerves to the deeper part of the cerebellum. By going to the anterior side of the sinus we have a more direct path in case the abscess lies deep. Special care should be used not to injure the facial nerve. The outer or posterior route gives more dependent drainage and is in a less infected field but the abscess is more likely to be missed. In the inner or anterior route, the posterior bony wall of the ear operation field is removed, laying bare the inner margin of the lateral sinus. The dura is raised and the field—a very small triangle—exposed, bounded by the facial nerve and the sinus, a dangerous area for one not intimately acquainted with aural surgery. The dura is cut horizontally keeping the edge of the sinus in view. The exploring needle is passed backward, inward, and slightly upward. By the outer route which is somewhat easier, an incision is made transversely backward from the original skin incision. The scalp tissues are elevated and the bone removed, exposing the sinus and going backward until the dura below is exposed for at least an inch in each direction. The incision of the dura is parallel with the sinus and below it. The cerebellum is now explored by passing the exploring needle inward and slightly upward, since the abscess lies near the anterior surface of the lateral lobe. If found, drainage is instituted as described above.

If the destruction of bone suggests the temporosphenoidal lobe, or if for any other reason it is desired to explore the lobe from the ear, one proceeds as follows: The roof of the operation cavity is removed, going inward, upward and forward. If no extradural abscess is found, the dura is incised. The presence of serous meningitis may explain all of the symptoms, but on the other hand such a meningitis often accompanies an abscess. The exploring needle is pushed upward for three-fourths of an inch; if no pus is found it is inserted forward and upward, and then backward and upward. Do not go too deeply since the abscess is generally near the surface in the inferior lobe.

Whenever the dura is to be opened, the field should be cleaned as well as possible, painted with tincture of iodine, and if space permits, the subdural space around the edges packed with gauze. If only a small incision is made in the dura, the brain bulges into the cut so as to practically obliterate the spaces.

In the second method, after cleaning out the ear and mastoid, search of the temporosphenoidal lobe from a separate opening is carried out by one of two ways: either the skin incision already made may be continued upward and forward to expose an area one inch in diameter, the central point of which is one inch above the posterior margin of the external auditory meatus, or we may use a small subtemporal muscle-splitting operation over the inferior temporosphenoidal lobe.

If we wish to enter the cerebellum by a separate opening, a line is drawn from the occipital protuberance to the external auditory meatus and a trephine opening is made 1 cm. below this line and $3\frac{1}{2}$ cm. behind the auditory meatus. The bone opening is enlarged as necessary. The dura is opened and the brain explored as described above.

If the third method is chosen, after the ear and mastoid have been cleaned out, the bone may be cleared off and a trephine entered one inch behind and one-quarter inch above the external auditory meatus. This will expose the sinus. By removing bone above and anteriorly the temporosphenoidal lobe may be reached, and by removing it downward and backward the cerebellum may be reached.

3. *In chronic cases with a primary focus* present, the same three courses of treatment are open as above. There is some slight advantage in opening the two fields separately since if no abscess is found there is less danger of infection; on the other hand, by operating through the ear there is greater probability of identifying the "stalk" mentioned and thus following it to its source.

4. *In chronic cases with localizing signs without a primary focus being present*, either a one- or two-stage operation may be done. The latter is certainly safer and where delay is not dangerous is worthy of consideration. In either case the area is reached by one of the extradural routes mentioned above for the individual lobes.

In Körner's series of 212 temporosphenoidal abscesses, the best results were obtained when the abscess was opened by the mastoid route, and by direct trephining of the skull; the next best by opening through the mastoid route; while the poorest results came from direct trephining without operation on the mastoid.

If good results are to be obtained in the treatment of brain abscesses the surgeon must be prepared to operate on evidence which amounts to much less than certainty and expect to fail in finding the abscess in a certain number of cases.

Thrombosis of Intracranial Blood Sinuses.—Diagnosis.—These present the evidences of obstruction to the return of blood through the afferent veins, and if the process is an infectious one, the symptoms of local inflammation and general septic phenomena. From a surgical standpoint thrombosis of the lateral and cavernous sinuses is most important particularly the former, although the longitudinal and other sinuses may be involved.

When the cavernous sinus is the seat of thrombo-sinusitis, we have cyanosis of the orbital and the frontal regions with protrusion of the eyeball. Pain along the first branch of the fifth nerve may be present with possible paralysis of the third, fourth, and sixth. To these signs are added the fever, leukocytosis, chills, etc., associated with sepsis. When the lateral sinus is involved, the origin is frequently from an otitis media. We will therefore commonly have the evidences of this disease and superimposed upon it the signs of occlusion of its afferent vessels, producing headache, edema posterior to the ear, dilatation of the cutaneous veins; secondly the signs of local infection, as tenderness; thirdly, the local and general evidences of extension of the clot down the jugular vein, with tenderness in the neck, torticollis, and the cordlike feeling of the vessel due to the clot therein; fourthly, the evidences of sepsis, with chills, fever, and the signs of extension of the septic process into the lungs; fifthly, the effect upon the nerves, since at times the ninth, tenth, eleventh and twelfth may be involved and paralysis ensue. It is seen, therefore, that early the signs may simulate an extradural abscess, or brain abscess, since the impaired circulation may produce a choked disk, vertigo, vomiting, slow pulse, stupor, excitability, etc., with the signs of infection. If the signs of pyemia develop with involvement of the jugular, the diagnosis is clear. Operation, however, should be performed early before these complications develop.

Treatment.—If we hope to aid these cases, the operation should be done before the stage of sepsis. Therefore, in the *lateral sinus cases* we should give prompt attention to any evidence of extension from an otitis media, the operation being planned to care for any complication that may be present, whether an abscess or a sinus thrombosis, and we should be guided by the findings as the operation progresses. If the extension to the jugular is evident or pyemia develops, the attack may then be made directly upon the sinus or the jugular vein as the case seems to demand. In connection with the consideration of the technic in these cases, the section upon brain abscess should be noted. Jones recently collected from English surgeons the various opinions as to the procedure in these cases, and correlated them as follows:

In every case of temporal bone disease with symptoms suggesting the presence of a perisinus abscess or the onset of pyemia, expose the sigmoid sinus with the least possible disturbance to its walls until healthy wall is seen and the blood in the part is judged to be fluid and the lumen controllable. This may involve removing bone up to, or even including, the covering of the torcular herophili, and down to within reach of the jugular foramen. If no disease is apparent except the extradural abscess and the so-called "healthy" granulations springing from the sinus wall, and if only one rigor has been observed—wait. If the pyemia is established but not severe and there is a limited occluding clot in the sigmoid, compress above and below clot, remove clot, excise outer wall between the compresses, and pack with gauze. If the sinus is obviously diseased, but contents are partly fluid and systemic symptoms marked, expose the internal jugular vein in the neck. Even if the sinus is not obviously diseased, and the blood is fluid, and there is severe pyemia or symptoms of bulb-thrombosis, expose the internal jugular vein, occlude both sinus and vein, drain, and plug the intervening part. If the sinus is clotted and the lower limit of diseased wall or clot cannot be reached, expose the vein in the neck—this is merely applying the principle of exposing healthy wall beyond each end of the clot without undertaking the much longer and generally unnecessary operation of exposing the bulb. Having laid bare the internal jugular vein at the entry of the common facial vein, we have several courses to consider. If the vein is of normal size and looks healthy, and if blood is flowing freely through it, compress temporarily and remove the clot from the sinus down to the jugular foramen; if there is a free flow of blood into the sinus, plug the sinus after draining and either close the neck wound or put in Voss' provisional ligatures, according to the severity and duration of the systemic symptoms. If the vein is collapsed above the facial, but healthy and full of fluid blood below, tie in two places and divide above the facial, bring the upper end into the wound, and endeavor to clear out the clot from the bulb by gentle irrigation. The same procedure can be adopted if the upper vein is clotted but the clot does not reach to the facial vein and the lower vein is healthy. It is easier to clear the bulb under these circumstances than to do so when the vein is collapsed.

When the clot extends beyond the facial junction it is better to tie and divide the internal jugular as low down as possible in the neck. Having dissected up the vein and tied off the tributaries including the facial, excise the greater part and bring the upper end into the wound. There is always a temptation to leave the vein unopened the first day, for fear of severe hemorrhage, but the risk of extension of sepsis from the upper vein is too great, and drainage from sinus to vein should be established at once. The wound in the neck may be closed, except the upper inch without packing, unless the walls of the vein are diseased, though the danger of suppuration along the trachea is a real one. Associated cerebral and cerebellar abscess, meningitis, metastatic abscesses must, of course, be dealt with as occasion demand.

The *approach to the cavernous sinus* may be laterally by way of the middle fossa, through the orbit, or through the nose. The former would be used in exceptional cases only. Mosher has described a method of draining the sinus through the orbit as follows:

The eye and the orbital contents are removed, the ophthalmic artery tied, the periosteum cleaned from the posterior half of the floor of the orbit, and the groove recognized in which the superior maxillary nerve runs. The periosteum is now separated from the orbital surface of the great wing of the sphenoid, and the outer end of the sphenoidal fissure recognized. Now place the chisel vertically and make a cut through the great wing of the sphenoid from the notch for the superior maxillary nerve to the outer end of the sphenoid fissure above. Enlarge the opening, making the lower level of the bone window on a level with the floor of the orbit. Elevate the dura from the floor of the middle fossa, the outer wall of the sinus being exposed, place a blunt-pointed knife against the sinus on a level with the floor of the orbit and carry the knife toward the body of the sphenoid, thus opening the sinus.

To those familiar with intranasal surgery, the following route will probably be found more satisfactory.

Langworthy has proposed an operation as follows: Light ether vapor anesthesia. Plugging of posterior nares on one side and free injection of adrenalin chloride solution about the operative region. Quick removal of obstructing ethmoid labyrinth, middle turbinate, and anterior sphenoidal wall, by the use of ethmoid curette, turbinate forceps, sphenoidal curette, punch, and long narrow-handle gouge and hammer. Once in the sphenoid cavity the author's straight and angular blunt curettes with overhanging edge can be pushed through the roof of the sphenoidal sinus close to the junction of its roof and external wall. The blunt ends of these curettes will push the carotid artery aside without damage and by rotating the spoon in a forward direction away from the carotid artery the overhanging edge of the curette catches bone and a hole of some size can be made leading directly into the sinus. This can be further enlarged by use of curettes assisted as mentioned by a long narrow chisel and hammer. The chief danger of the operation here I would say is not quite so much the thick-walled large carotid artery but rather some unexpected small branches given off frequently in this region which when accidentally torn by instrumentation might prove troublesome—much of this, however, is at present pure speculation.

Tuberculous Meningitis.—Diagnosis.—The diagnosis must be made on the evidences of a meningitis developing more slowly than the acute meningitis, the presence of a possible source, the age of the patient, and the findings in the cerebrospinal fluid. The disease is found most often in children who are poorly nourished. There is frequently a prodromal stage of restlessness and sleeplessness followed by headache. In a week to a month the evidences of meningitis appear, with muscular twitchings, cranial nerve involvement, and finally delirium, coma, paralysis, etc. Variable temperature is present and the spinal fluid is clear with a lymphocyte increase; in exceptional cases the spinal fluid may be purulent or bloody; deceptive remissions occur.

Treatment.—Operative treatment such as decompression, repeated lumbar puncture, etc. have been tried, but without influencing the course of the disease. It hydrocephalus follows it may be treated by corpus callosum puncture.

Syphilis of the Brain.—The protean picture presented by syphilis of the brain is the cause of failure in *diagnosis* by the novice and the most suggestive factor in diagnosis to the expert. This is due particularly to the many forms the disease may take, from a simple meningitis to arterial changes and their consequences, or even to solitary or multiple intracerebral manifestations. They may occur as early as three or four weeks or as late as many years after infection, while isolated gummata may appear indistinguishable in symptomatology from brain tumor except for the serological findings. There is most often an atypical picture involving both brain and spinal cord. In almost all cases where present the disease may be suspected and must be confirmed by the Wassermann reaction, before absolute diagnosis is possible. Among the suggestive symptoms are headache, motor disturbances, cranial nerve involvements, spinal complications, disorders of sleep, alterations of character, and sensory phenomena. It is evident that these are not peculiar to brain syphilis, and yet a careful study of them may be suggestive. The headache is often most severe, being described as throbbing, boring, etc., it is recurring and fairly constant, and may be the only symptom or may be associated with vomiting, dizziness, and choked disk, especially in gummata, and in cases where no assignable cause can be found for such a headache, serological tests should be made of both the blood and spinal fluid. Motor disturbances are fairly common, varying from a Jacksonian epilepsy seen with gumma, to twitching, spasms, localized and atypical paralysis. Hemiplegia is not uncommon and when it does occur before the natural age and without high blood-pressure is suggestive. The cranial nerve most often involved is the third, but any others may be so affected, especially the fourth and sixth. Alterations of character may be marked: the active may become sluggish; the thrifty, profligate; the moral, immoral; or less prominent characteristics changed.

Insomnia is a very common complaint and when found should lead to investigation.

The sensory changes are most variable but a rather constant symptom of brain syphilis.

Treatment.—The treatment of brain syphilis calls for most persistent attention. The common belief that potassium iodide has any curative value in the condition should be discounted. It does give relief to symptoms, and may cause a recession of the gummatous and syphilitic deposit, but does not act to destroy the spirochetæ. For this purpose either arsenic or mercury are necessary and at times the administration of both will be of advantage. The mercury should be given in large doses and persistently. There is nothing superior to the rubbings with blue ointment, but the deep muscular injections in various forms are also efficacious. Salvarsan either intravenously or intraspinally may be given. It is thought by Hall and others that dissolving the drug in the aspirated cerebrospinal fluid and reinjecting it into the subdural space may produce better results. This should be repeated frequently and is best supplemented by mercury treatment. The treatment should be continued until the Wassermann remains negative for at least a year, and it is wise to make subsequent tests and keep the patient under observation for a number of years. Hamill who has had considerable experience in the treatment of cerebrospinal syphilis summarizes his views as follows: Syphilis of the nervous system is to be treated as syphilis whether early or late. If early intravenous methods probably suffice, but they must be controlled by Wassermann on the blood and spinal fluid. The method producing the most favorable results is an intermittent one: three or four injections at four- to seven-day intervals, two or three months of rest with intramuscular injections of mercury and then another and even a third series. Late nervous syphilis should receive both intravenous and local treatment, if we may so term subdural injections.

In those cases presenting persistent brain pressure symptoms, threatening loss of sight, a subtemporal decompression or puncture of the corpus callosum may be indicated.

THE PURPOSE AND TECHNICAL STEPS OF A SUBTEMPORAL DECOMPRESSION.[1]

By HARVEY CUSHING, M.D.

The view, long held by some neurologists, that intracranial tumors are of far more frequent occurrence than the usual morbidity figures would indicate, has, during the past decade, come to be generally accepted. That the profession has been slow to appreciate this is not to be wondered at, for few have been trained along neurological lines, and even those who were, have hesitated to make a diagnosis of tumor unless the so-called classical features of an advanced process were present.

When, however, under the caption of "brain tumors," we include growths not only of the encephalon but also of its meningeal coverings and of its appendages, choroid plexus, pituitary and pineal bodies, the symptoms which may be evoked are diverse in the extreme, and, indeed, there may be no appreciable symptoms whatsoever until late in the course of the disorder and even then unclassical ones. For, regarded broadly, intracranial tumors are of most varied sorts, in most varied situations, and, as they differ greatly in their rapidity of growth, the resultant symptoms vary widely in character and degree.

Surgery has had much to do with this change of opinion, for the promise of operative relief in what is otherwise a hopeless condition has led to more precocious and more exact methods of diagnosis. It is but a repetition of our experience with the disorders of the appendix, of the gall-bladder, of the stomach and duodenum: for a few years ago an ulcer of the duodenum was a rare malady, with certain classical symptoms, for which we do not now sit and wait.[2]

Most tumors, first or last, lead to the classical symptoms of headache and choked disk—the chief subjective as well as the most reliable objective indication of intracranial pressure. Though pressure dis-

[1] Received for publication May 6, 1916.

[2] Seven years ago (Boston Med. and Surg. Jour., 1909, clxi, 71–80) the writer had occasion to examine the incidence of brain tumor cases in the Johns Hopkins Hospital records and found that in approximately 25,000 admissions in the medical wards over a period of twenty years there had been about 100 cases diagnosed as tumor or presumptive tumor. As there were about 20 cases in each successive 5000 admissions, 0.4 per cent. may be taken to represent the average incidence of tumor in a general medical clinic which receives neurological cases. In the surgical service during the same period, due to the growing interest taken in these disorders, the percentage had risen from 0.06 per cent. in the first 5000 admissions to over 3 per cent. in the last 1000. In the first 5000 admissions to the surgical service at the Brigham Hospital there have been, including pituitary tumors, approximately 400 tumor cases, 8 per cent., or one in every twelve admissions, and something over 100 cases a year. This shows how attention paid to a special subject may modify the character of a clinic.

comforts may sometimes undergo spontaneous retrogression, as in a child with a distensible skull or in the case of a pituitary tumor which succeeds in distending the sella turcica, still in the general run of cases a persistent increase in intracranial tension if unrelieved by surgical measures leads to great physical suffering and ultimately to loss of vision. For the purposes of our present topic we may turn our attention for a moment to these two most characteristic evidences of tension.

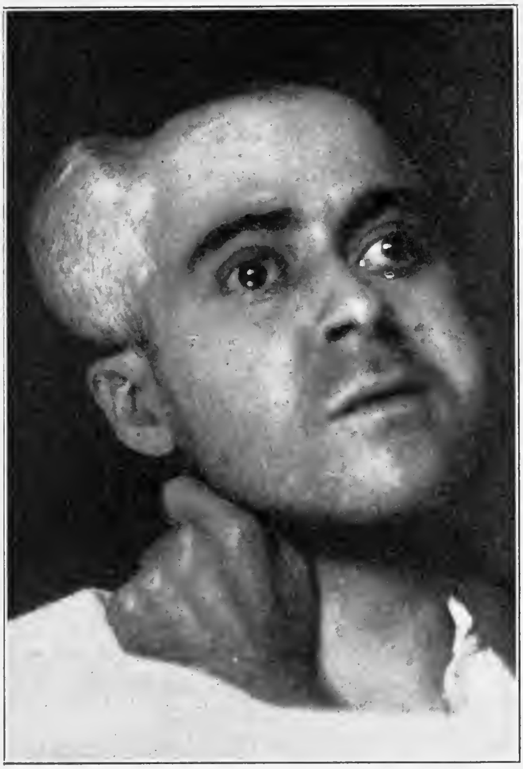


Fig. 135.—Example of an improperly placed and improperly executed so-called "decompression" for presumed cerebral tumor (actually a cerebellar endothelioma with secondary hydrocephalus). Note curvilinear incision and position of defect too high to be protected by muscle. Insecure closure of wound led to a cerebrospinal fluid leak; the extreme protrusion to contralateral hemiplegia. (Compare Figs. 177–180.)

The swelling of the nerve head commonly called a choked disk or more appropriately a papilledema is properly regarded today as largely a mechanical process due to the stasis of cerebrospinal fluid under tension within the subarachnoid space of the optic nerve sheaths. The fluid finally backs up in the optic nerves themselves, entering, according to Schieck,[1] at the points where the vessels penetrate the

[1] Die Genese der Staungspapille, Wiesbaden, 1910, p. 91.

nerves, thus producing a chronic edema which ultimately leads to destructive scar formation. The cerebrospinal fluid element, therefore, is the important one and a choked disk depends more upon the situation than on the size of a tumor. Thus a slowly growing tumor of a cerebral hemisphere may reach large dimensions before a choked disk appears, whereas a small growth accompanied by a widespread cerebral edema or one which is in the hind brain and interferes with the cerebrospinal fluid outflow through the iter may lead to a high grade of the process as

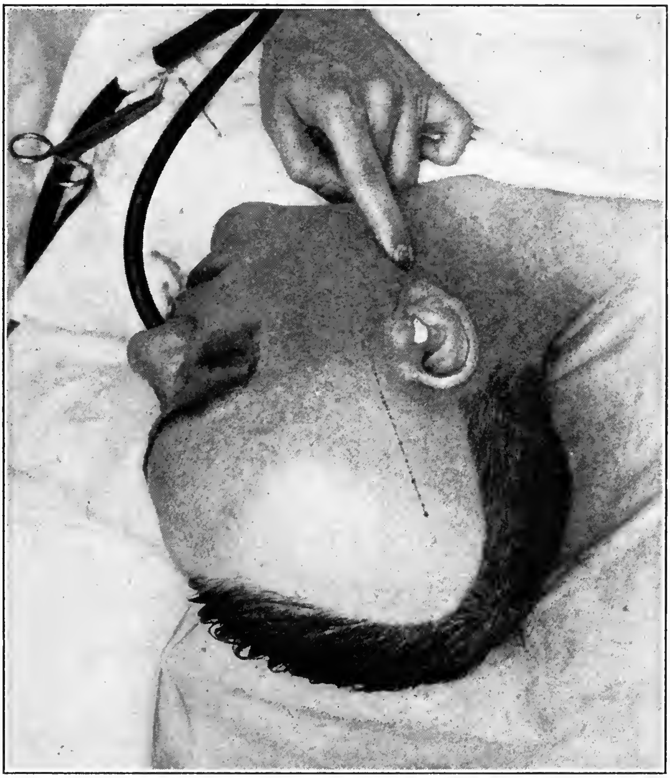


Fig. 136.—Showing intranasal ether administration; area of shaving; primary epidermal incision.

an early symptom. On the other hand, tumors such as pituitary tumors which press upon the optic nerves and thus prevent fluid being forced down the optic sheath are rarely accompanied by a choked disk, even though they ultimately may reach such a size as to cause an internal hydrocephalus from obstruction of the foramina of Munro.

Headaches, too, are attributed to tension and they vary considerably in their situation and intensity. Occasionally the discomforts are of localizing value, as is true of suboccipital headaches accompanying cerebellar tumors and the bitemporal headaches characterizing pituitary growths, but as a rule they are described as a general unlocalized pressure discomfort which may be so intense as to stupify and to give a sensation as though the head would burst. It is not entirely clear just what produces the sensation of headache, for the brain is insensitive. The dura, however, is a sensitized structure, its nerve supply being wholly trigeminal except for a small area around the foramen magnum which is innervated by the vagus, and in all likelihood the discomforts may be ascribed to stretching of this membrane, or its expansions into falx or tentorium. Certain observations lend support to this view. Thus, after a total trigeminal neurectomy for neuralgia such headaches

Fig. 137.—Layer of wet bichloride gauze.

as may follow the operation, whether from the anesthetic or loss of cerebrospinal fluid, are usually referred by the patient to the sound side on which the dura retains its sensation. Then again, certain forms of headache associated with an enlargement of the pituitary gland are evidently due to distention of the dural capsule of the gland, for they are apt to cease when the growth finally breaks through the capsule just as they may cease abruptly after a transsphenoidal operation in which the floor of the sella turcica has been removed and the dura incised (sellar decompression). These things make it probable that distention of the sensitized dura is at least an important element, if not the primary element in those forms of cephalalgia which are associated with a local or general increase of tension.

Extirpation of a lesion, wherever it may happen to be and particularly if it be a new growth, is the ideal surgical procedure, but a valuable alternative and the only alternative in the case of an intracranial tumor which cannot be definitely localized, or if localizable proves inaccessible, is to relieve the factors of tension which are producing these symptoms. The idea of a purposeful operation which has as

Fig. 138.—Primary circular toweling pinned in scalp.

its objective the mere relief of pressure in these conditions was slow in its development. This may doubtless be attributed in part to the confusion which long existed regarding the causative factor in the production of a choked disk for, as the long-used term "optic neuritis" signifies, the process, in the minds of many, was due to an inflammation or to some sort of neurotoxic effect on the optic nerves produced by the growth. From this viewpoint, an operation which did not serve to remove the tumor could hardly have been expected to check the optic neuritis. Some ten years ago, however, the early view that the process was largely mechanical, rather than toxic or inflammatory, was revived and came to prevail; and not the least important argument in its favor was the fact that exploratory operations which had failed in their object of tumor removal sometimes served unexpectedly to relieve headaches and, what was more, to preserve vision.

It is remarkable that this was not appreciated earlier, for neurologists and surgeons must often have seen examples of spontaneous palliation of symptoms, such as may follow the pressure absorption, by a subjacent tumor, of the overlying skull, or the diastasis of the sutures in

Fig. 139.—Secondary toweling pinned in tragus.

pre-adolescent individuals, with consequent relief of headaches. However, a discouraging opinion regarding the futility of all operations for tumor, except those involving the motor cortex, had been pronounced in Germany by von Bergmann and in this country by Agnew. Cases, if operated upon at all, were apt to be operated upon late in the disease, when a choked disk was so far advanced that blindness might ensue even though a tumor was removed and tension completely relieved. Moreover, the methods of entering the cranial chamber, and particularly of closing the wound afterward, were so imperfect that when great tension was encountered, a fungus cerebri and its distressing consequences often followed. But despite all discouragements, some surgeons, notably Sir Victor Horsley, persisted in their efforts to relieve these cases and urged that more precocious explorations be made on the basis that they might serve to palliate the major pressure symptoms even though no tumor be found and removed. This possibility that an exploratory operation which fails to disclose an expected tumor may nevertheless afford unexpected relief was first clearly expressed, so far as I am aware, by Robert F. Weir[1] in 1888 on the basis of a single

Fig. 140.—White operative sheet with indented opening and tapes.

experience. Similar experiences were soon recorded by others (Horsley in 1889, Sahli in 1891, Jaboulay in 1893, Annandale, Keen, Sänger and Bramwell in 1894, etc.), as Spiller and Frazier[2] in an article on the subject have pointed out.

A cranial exploration which is unsuccessful in its purpose of tumor exposure and removal can, however, hardly be placed in the same category as the present day purposeful decompressive craniectomy, and

[1] Weir and Sequin cit., cf. H. Cushing: Jour. Am. Med. Assn., 1909, lii, 184–192.
[2] Jour. Am. Med. Assn., 1906, xlvii, 679, 744, 849, 923.

though these operations doubtless grew out of them, it was many years before the idea got a footing among the profession in general. Among the earliest to clearly advocate a craniectomy for the relief of pressure symptoms was Victor Horsley,[1] first at the Berlin Congress of 1895 and three years later at a meeting of the British Medical Association. At that time he favored a large bone defect over the accessible portion of the hemisphere thought to be involved but without opening the dura. The term *trépanation décompressive* was adopted in France by Jabouley[2]

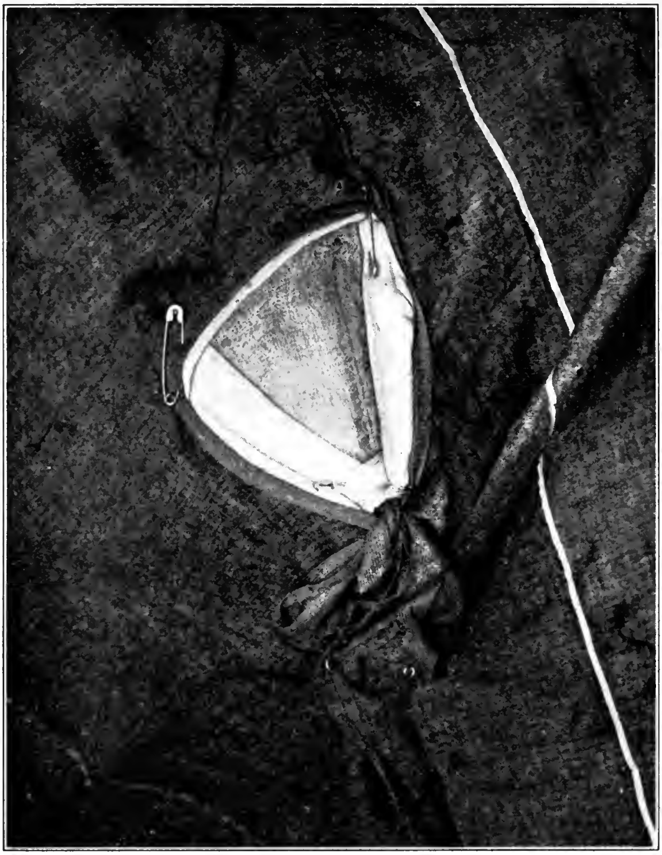


FIG. 141.—Final gray covering.

in 1896 and in the same year employed by Broca and Maubrac[3] in the sense in which we now use it. At the outset it was supposed that an opening made anywhere in the skull would serve the purpose, but great hesistancy was expressed by all in regard to the propriety of opening the dura, as a substitute for which Sänger advocated a ventricular, and Broca and Maubrac a lumbar puncture.

[1] British Med. Jour., 1890, ii, 1286; Ibid., 1893, ii, 1365.
[2] Lyon méd., 1896, lxxxiii, 73.
[3] Arch. gén. de méd., 1896, i, 129.

Most of the early operations for tumor have been undertaken in cases in which the paracentral (sensorimotor) convolutions were presumably involved, for the very evident reasons that here a localizing diagnosis is comparatively simple and the area is the most favorable for surgical access. Unhappily, however, if a tumor were not found and tension proved to be great, a formidable protrusion often occurred with marked

FIG. 142.—Fingers as tourniquet preliminary to incision.

accentuation of the preëxisting local symptoms, even though the subjective headache and the choked disk might have been relieved. Then if the exploration happened to be made over the leading hemisphere and aphasia was superadded to the hemiplegia, the patient's helplessness was so accentuated as to entirely outweight the subjective relief.

Though Byron Bramwell and Bruns had somewhat hesitatingly advocated purposeful trephining for palliative purposes, Sänger was one of the first neurologists to speak emphatically on the subject[1] and in 1902[2] he advocated the establishment of a cranial and dural defect over a relatively silent area of the brain, his favored site being the posterior portion of the right hemisphere. This procedure, however, may lead to an unsightly and unnecessarily large protrusion, particularly when, as is often the case, distention of the ventricles is a complicating factor (Fig. 135), and ten years ago, for the first time I believe,

Fig. 143.—Clamps placed on galea, liberating fingers of one assistant.

a description was given of operative methods which had for their object the purposeful herniation of a silent area of the brain under a muscular protection.[3]

[1] He then wrote: "Palliative trepanation in case of cerebral tumor is an operation which even if not absolutely free from danger is of extraordinary blessedness, and, in the hands of a practiced surgeon, one that I would like to recommend in every case, in consideration of the impotency of internal medicine, in view of the distressing suffering, and, above all, of the menacing blindness."

[2] Sänger: Deutsch. Gesell. f. Chir., 1902.

[3] Cushing, H.: Surg., Gynec. and Obst., 1905, i, 295–314.

Considering the fact that these matters are all of such comparatively recent date, it is no occasion for surprise that those who have not followed them closely still have somewhat hazy ideas concerning the principles involved in a cerebral decompression, which, to recapitulate, arose from the finding (1) that a craniectomy with a sufficient opening of the dura may relieve headache and choked disk even without tumor removal, (2) that a craniotomy over an important cortical area may lead to functional injury of that area in consequence of the ensuing protrusion, (3) that, therefore, the defect in the bone and dura should

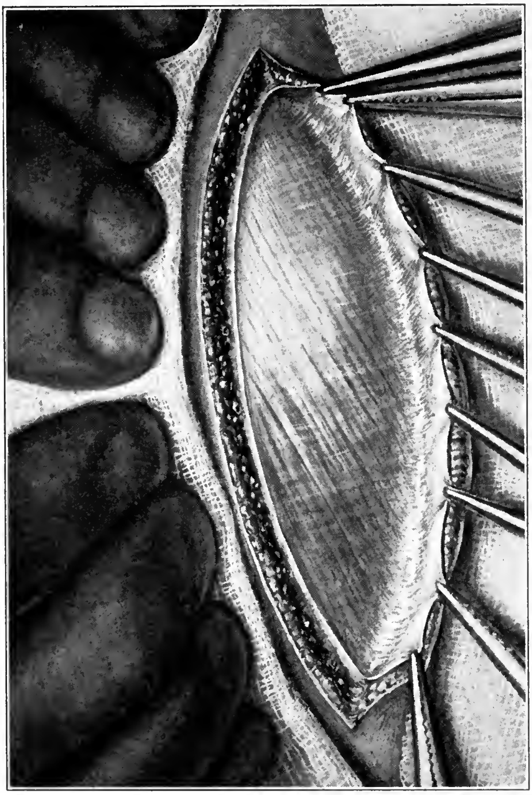


FIG. 144.—Showing proper placement of clamps. (Natural size.)

be made over a relatively silent area of the brain, (4) that this area if protected only by scalp often leads to a most unsightly and unnecessarily large protrusion and hence, (5) that if possible it is wise to decompress for supratentorial lesions over an area which can be protected by the careful closure of moderately resistant tissues, such as are afforded by the temporal muscle and its fascia.

In 1905 when the palliative operation which embodied these principles was first described, experiences with it had been few and its actual value was somewhat problematical. The operation was unwisely called an "intermusculotemporal" procedure from the desire to emphasize that the temporal muscle and fascia were split as in the intermuscular laparotomies which avoid the transsection of muscle fibers. For this cumbersome name the better term "subtemporal" craniectomy or decompression was later substituted.

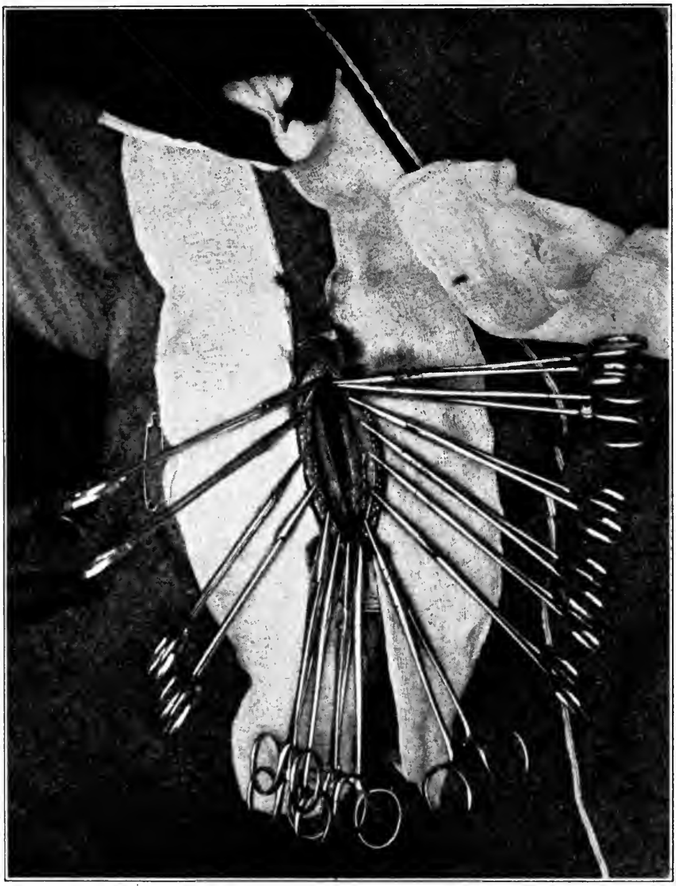


FIG. 145.—Incision through fascia.

The operation, furthermore, must have been badly described, for many seem to have gained the impression, possibly from the illustrations of an incomplete stage of the procedure, that the dura was not to be opened; unfortunately, too, a curvilinear skin incision was advocated and pictured, the object being to still further accentuate the "gridiron" approach through the cranial coverings. It was soon found that this curved incision interfered with a possible subsequent osteoplastic exploration on the same side and was objectionable also since through it the base of the temporal fossa was difficult of access. Moreover it was found to be unnecessary, for with the separate closure of the galea by buried sutures, the scalp wound was found to be sufficiently secure even though it directly overlay the incisions through muscle and fascia.

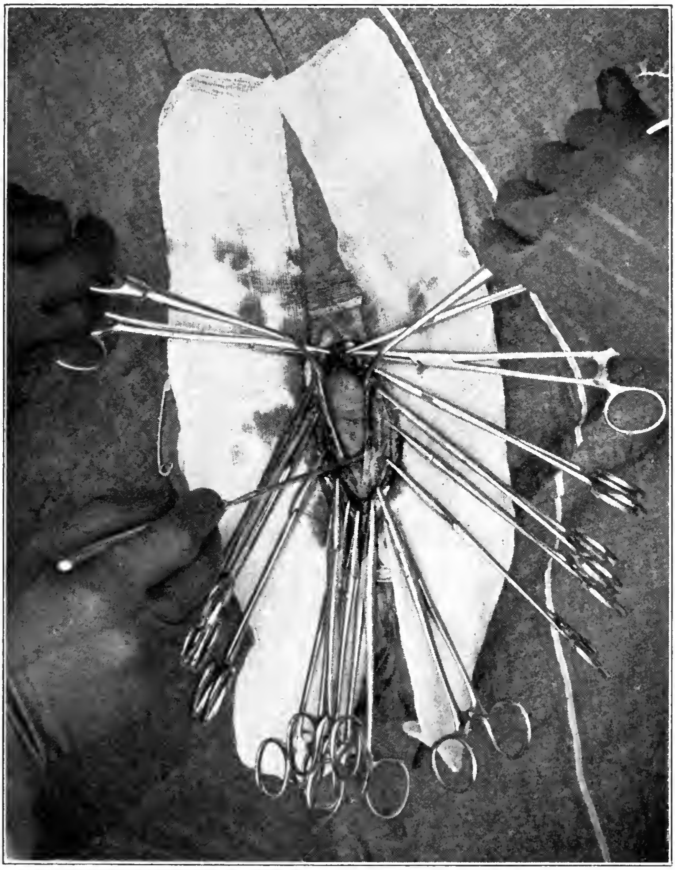


Fig. 146.—Elevation of temporal muscle after incision.

Fig. 147.—Form of elevator for temporal muscle. (Natural size.)

With the gradual adaptation of the operation to cases of basal fracture[1] in which a rubber tissue drain for cerebrospinal fluid is advantageously left emerging from the lower angle of the incision, a linear incision through all the layers came to be the approved method. This modification was described in 1908 but has apparently not been generally followed, judging from the examples of so-called subtemporal decompressions which frequently come under observation. Many of them have curvilinear scalp incisions with a cranial defect which is

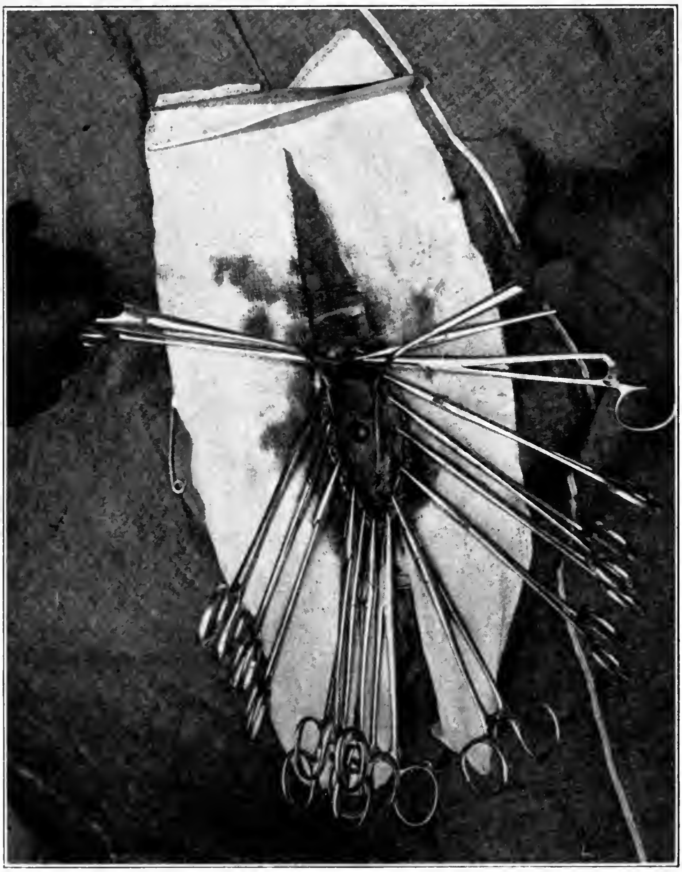


Fig. 148.—Primary opening with burr.

either too small to be effective even if the dura has been opened, which it often is not, or so high that contralateral paralyses may be expected; and in not a few a bone flap has been turned back and replaced. From these ineffective procedures it is clear why objections to the operation have arisen on the score of too small an opening or of distressing consequences when the opening is sufficiently large (*cf.* Fig. 135).

[1] Cushing, H.: Ann. Surg., 1908, pp. 641–644.

Though the simplest and safest of all the operations which are called for in the various surgical problems presented by intracranial tumors, there nevertheless are technical difficulties connected with it which demand practice and properly constructed instruments, but this is true enough of all craniocerebral procedures. In the course of some three or four hundred decompressions we have learned how to avoid operative complications and accidents, and it is the purpose of this article to describe in detail the various steps of the procedure. Some of

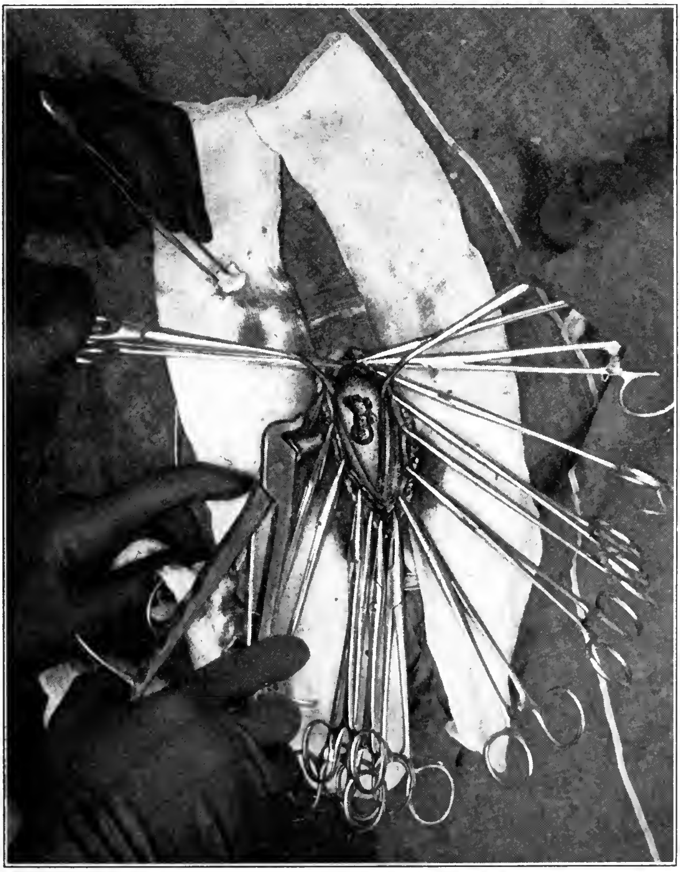


FIG. 149.—Further enlargement with Montenovesi forceps.

the technical improvements adopted since the early description of the operation fourteen years ago lie in the use of gray operating sheets, in the control of hemorrhage from the scalp by digital compression, in the use of silver clips for the meningeal branches divided with the dura, of proper retractors to elevate the muscle, of the spoon spatula to control marked cerebral protrusion during closure, of ventricular puncture to lower tension and to aid in diagnosis, and finally in the method of closure in three or four layers of buried sutures including the fascia and galea.

The accompanying photographs were taken during the course of the usual decompression for an unlocalized tumor and the comparative freedom from blood staining can be taken as an evidence of the effective hemostasis, though admittedly all of these operations are not

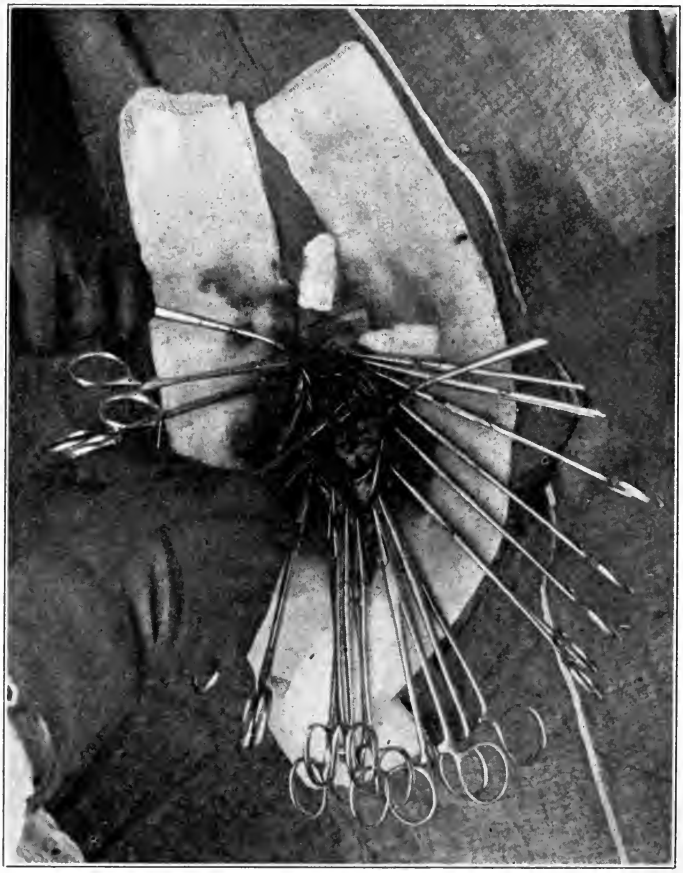


Fig. 150.—Introduction of flat rongeurs well under muscle for further enlargement.

equally dry. For convenience of description we may divide the procedure into the following steps:

A. Anesthesia and preparation of the field (Figs. 136 to 141).

B. The incision to completion of the subtemporal bone defect (Figs. 142 to 152).

C. The dural opening and cerebral exploration, this being the essential part of the operation (Figs. 153 to 160).

D. The closure and dressings (Figs. 161 to 173.)

A. **Anesthesia and Field Preparation.**—The importance of exceptionally skilful anesthesia cannot be emphasized too greatly. Patients suffering from the effects of intracranial tension are notoriously bad

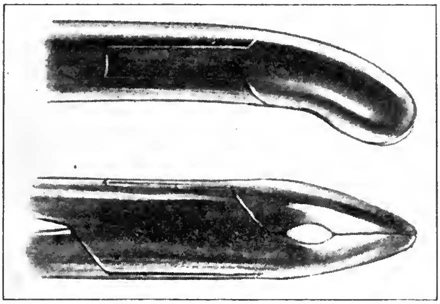


Fig. 151.—Flat-nosed rongeur for insertion under muscle edges. (Natural size.)

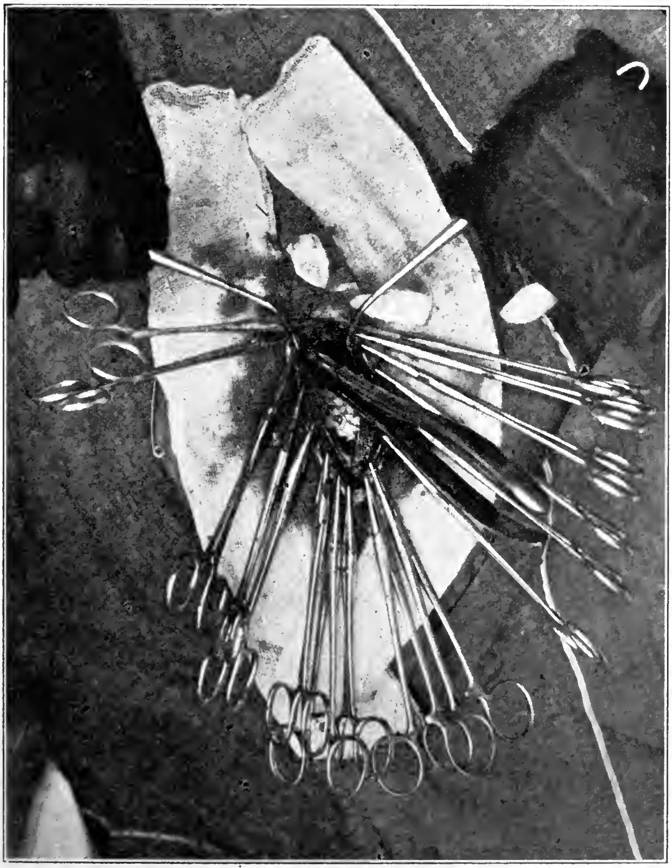


Fig. 152.—Same as preceding, rongeurs reaching well toward base of skull.

subjects for narcosis and different operators favor different methods and different drugs. Some advocate local anesthesia, which has its many objections. The inhalation narcotics are apt to increase tension owing to the increased secretion of cerebrospinal fluid which they apparently induce, and this is accentuated if the patient is permitted to become at all cyanosed, as is more or less inevitable with nitrous oxide. Chloroform or mixtures which contain chloroform have their

Fig. 153.—Primary incision in dura.

especial dangers and, taken all in all, straight ether anesthesia may be regarded as the safest and best method.[1] This was formerly given by the drop method throughout, but during the last four years, when

[1] The comparative freedom from ether accidents and operative difficulties owing to ether during many cranial operations in a long series of cases in the past ten years is due entirely to the exceptional skill of Dr. S. G. Davis, of Baltimore, and Dr. Walter Boothby, of Boston, who have anesthetized practically all of them. (*Cf.* This paper was written in 1914.)

secondary narcosis is once induced by the drop method and mask it is supplanted by ether vapor under a measured tension given by the Connell apparatus through a tube introduced through the nares into the pharynx. By this method the anesthetist is removed from the operative field and the induced sleep is usually so quiet and regular that the distracting anxiety concerning the anesthetic is eliminated.

The operative field is shaved the morning of operation. That shown in Fig. 136 is larger than necessary. All antecedent preparations of the scalp are to be avoided, for they accomplish little more than to give

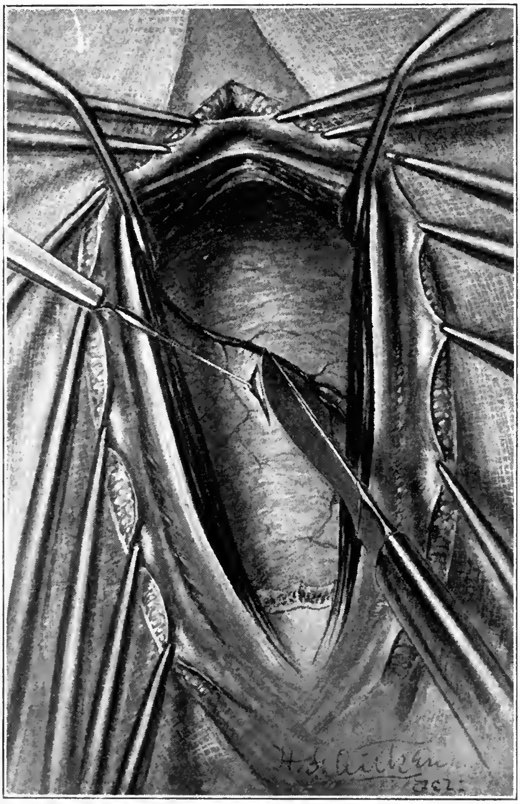


Fig. 154.—Same as preceding (natural size) to show dural hook.

the patient a restless night. These operations are palliative, it is to be remembered, and many of the patients may soon return to their occupations. Particularly in women it is desirable to avoid shaving more than the necessary small strip bordering the line of proposed incision. The hair should be brushed away and tightly braided in a single braid centering in the opposite parietal region. Cotton is placed in the auditory canal and the scalp is cleaned merely by sponging with some green soap followed by alcohol and bichloride. Personally, I detest iodin preparations.[1]

In all cranial operations the towels should be securely disposed closely about the wound and, to prevent slipping during the course of a possible prolonged operation, they should be pinned into the scalp, leaving nothing exposed but the actual line of incision. This means, therefore, the complete covering of all landmarks, so that it is custom-

Fig. 155.—Further incision on grooved director; note clips on vessels. (Natural size.)

ary before placing the towels to make an epidermal incision (Fig. 136). In the operation under discussion this scratch, about 10 cm. long, should run, with a slight obliquity backward, from the upper edge of the zygoma slightly in front of the ear to a point just below the parietal eminence.

[1] In the only infection in my entire series of decompressions, the patient's head had been completely shaved and elaborately scrubbed and disinfected. I was persuaded to operate in unfamiliar surroundings and a rubber dam tourniquet was employed, and there were other technical features of the procedure which were obviously bad. Unquestionably all complex craniocerebral operations should be home operations in the company of assistants fully trained to an established technic.

Over the entire head a layer of wet bichloride gauze is then thrown (Fig. 137) and with the head lifted by the orderly's hand under the neck, two layers of damp towels are placed under the head, carrying the gauze with them. The upper folded towel is then wrapped snugly about the head, catching at occiput and orbit, and is pinned into the scalp at the point of crossing at the upper end of the incision (Fig. 138). The next towel is then laid along the posterior edge of the incision and

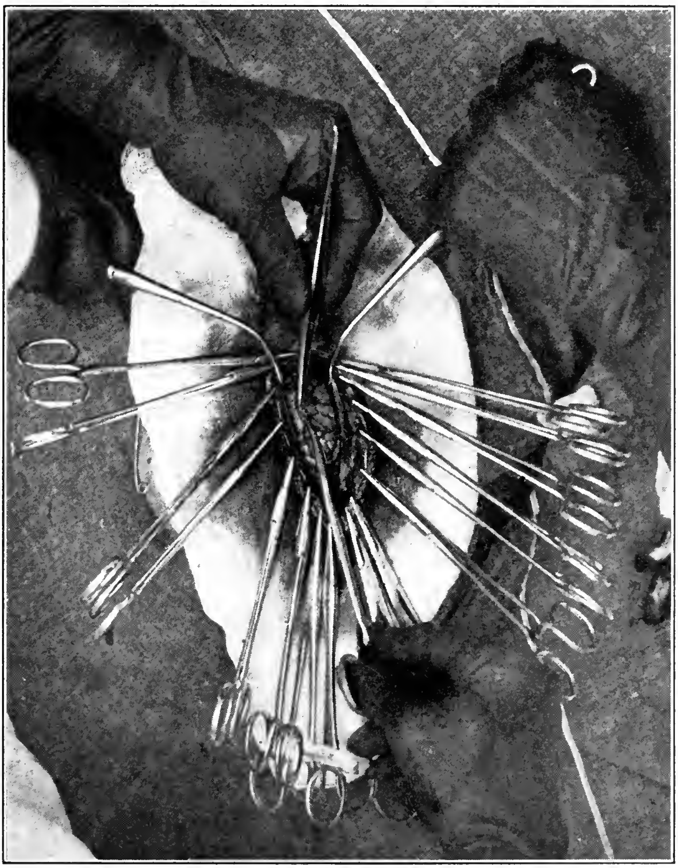


Fig. 156.—The placing of a silver clip on the bleeding margin of the incised dura.

when pinned into the skin in front of the tragus is wrapped around the head as shown (Fig. 139). This is followed by a large operating sheet which is thrown over the anesthetist's bracket, the instrument stand and all, and in the edge of which is a circular notch. The margin of this notch is caught under the pins and the tapes at its corners are tied around the field (Fig. 140). This is followed by the final gray covering (Fig. 141).

It sounds like an Irishism to say that the better the light the more difficult it is to see into a deep hole. But it is true, particularly when a wound is surrounded by the white operating sheets so commonly used which serve merely to contract the pupils and incommode vision. Then, too, in the course of most of these operations a head light is advantageously employed to throw a concentrated light directly on areas in the depths and with white surroundings there are annoying reflections.[1]

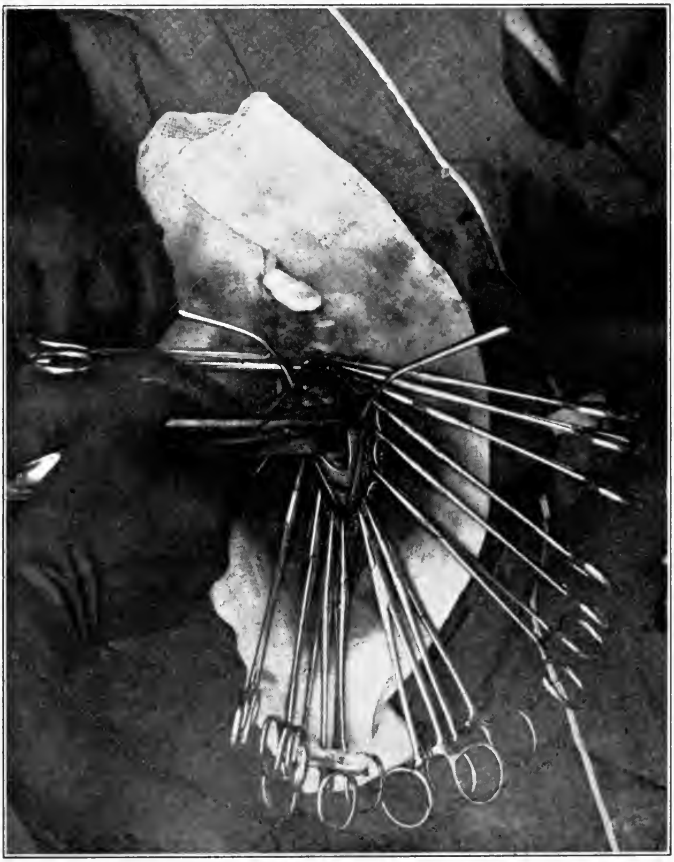


FIG. 157.—Lateral incision with spoon director.

There are doubtless other and equally good ways of placing these coverings, but what should be emphasized is that they must be anchored securely in position in view of the small linear field of preparation.

[1] A complete gray equipment for the operating room, including gowns and toweling, has been employed since the opening of the Brigham Hospital four years ago with increasing satisfaction. Others have long appreciated the value of color protection. Carrel has long used black, but this is too funereal for a hospital operating room, and the color soon rusts. Sherman speaks highly of the green equipment which he has installed in San Francisco. Gray we find particularly restful to the eyes, but almost anything is better than white, which has been so long employed.

B. **The Extracranial Incision and the Bone Defect.**—There are many ways of controlling bleeding from the scalp. In this particular operation the incision is made in the vascular temporal area and the vessels will be divided at many points. Our favored method in all cases is by finger compression made by the two assistants over gauze sponges laid along the margin of the epidermal scratch (Fig. 142) and these sponges remain undisturbed until the closure.

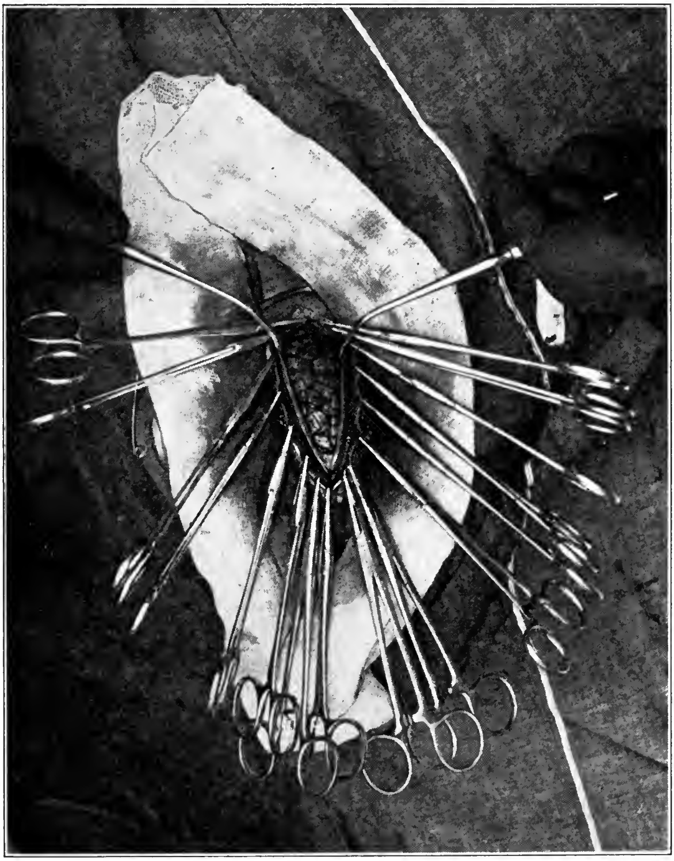


Fig. 158.—Lateral incision completed, brain protruding slightly.

After the incision has been carried through the galea aponeurotica down to the temporal fascia, the operator places a series of pointed Halsted clamps on the galea to the right, freeing the assistant on that side (Fig. 143). When the clamps fall back they fold the loose galea over the scalp and completely check bleeding without the necessity of including and crushing any of the fat in their jaws (Fig. 144). The hands of the assistant on the left are then freed in like manner.

The temporal fascia is then divided (Fig. 145) and after the incision is carried through the temporal muscle practically in line with its fibers, the muscle and epicranium are scraped from the bone by proper periosteal elevators (Fig. 146) while the muscle edges are held up by retractors of a particular form (Fig. 147). If the patient's mouth is closed, the muscle edges may be sufficiently elevated to permit the insertion of the rongeurs under them during the subsequent stages without putting such strain on the edges as to strip them from the skull at their upper margins of attachment along the temporal ridge. The muscle should be carefully freed from its cranial attachment well down in the temporal fossa, and from there up to its upper margin along the temporal ridge.

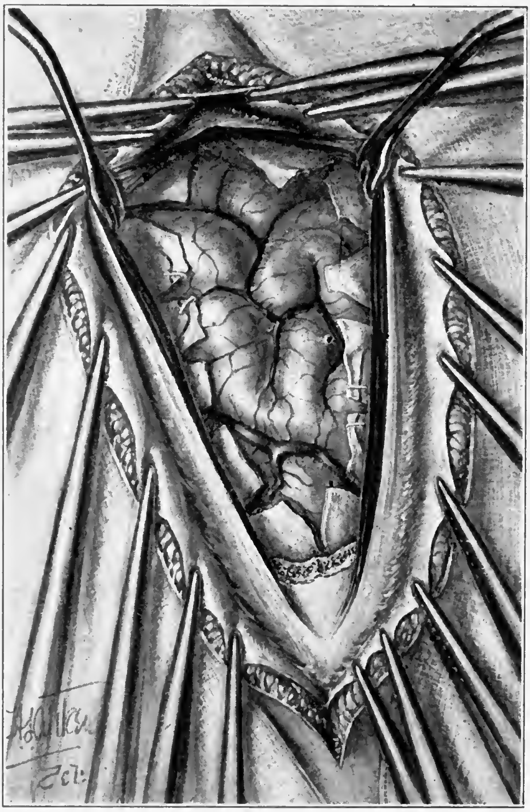


Fig. 159.—Same as Fig. 158 (natural size), showing the usual cortical appearance with Sylvian veins at the near angle of the wound.

In the center of the denuded area of bone a primary opening (Fig. 148) is made with a burr and this is enlarged downward with Montenovesi forceps (Fig. 149) until a sufficient opening is secured for the rongeurs. Successful rongeuring is one of the difficult features of the operation (Fig. 150) and requires very flat-nosed instruments (*cf.* Fig. 151), else they cannot be inserted under the muscle without stripping it from its attachments to the skull. If the patient has a very vascular diploë, the difficulties of rongeuring may be considerable and constant waxing of the margin is necessary. In the depth this cannot be done with the fingers without crowding the wax under the edge of bone, but it can be accurately placed and rubbed into the diploë by small flat pledgets of cotton wrung out from warm salt solution and held in a pair of forceps. It may be said that, to the complete avoidance of gauze, all sponging of these wounds and particularly of the brain itself is restricted to these damp cotton pledgets, which may be seen lying about in some of the photographs (*e. g.*, Figs. 150 and 152).

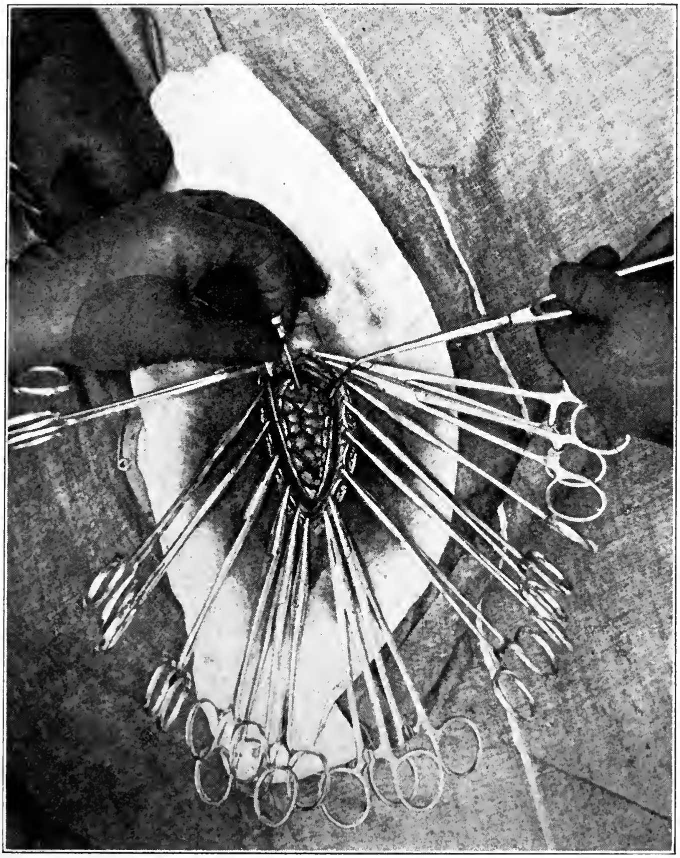


Fig. 160.—Insertion of curved aspirating needle into ventricle of temporal lobe.

The subtemporal bone is gradually rongeured away until as large an area as possible is removed, averaging in adults about 6 by 8 cm. Care should be taken to bite the fragments outward lest the brain be contused by the jump of the forceps and especial precautions must be taken in approaching the pterion, where the meningeal may be injured and the field flooded if the vessel is not controlled immediately. The thin plate of bone from the lower field well down in the temporal fossa is most easily broken out (Fig. 152) and should be thoroughly removed.

Before venturing to open the dura the field should be quite dry, for with a denuded and protruding brain it is most difficult to control any oozing left during this preparatory stage.

C. **The Dural Opening and Cerebral Exploration.**—It is in this, the vital stage of the operation, that experience is put to the test. As the dura is apt to be tense and the brain "dry," great care must be exercised in making the primary opening in the dura (Fig. 153) and after the first nick in the outer layer of the membrane, a fine curved hook may be inserted under it and the membrane drawn upon to facilitate a safe entry (Fig. 154). A grooved director is then inserted and the incision prolonged downward, "silver clips" being immediately placed (Figs. 155 and 156) on the branches of the meningeal before or after their division, as is most convenient.

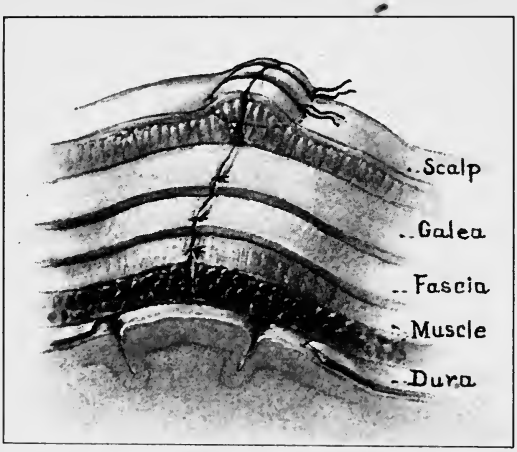


FIG. 161.—Diagram of the individual layers of closure.

These clips, useful for all operative work, were designed for this special purpose and particularly when the radial incisions are being carried well under the muscle to the margins of the bone defect where meningeal branches inaccessible to the ligature may be encountered, the device is an invaluable one. As the lateral incisions are cut it is well to protect the protruding temporal lobe with the spoon spatula lest it be injured (Fig. 157). A good deal of skill and expedition is required at this period, particularly if the tension is considerable and if contusions and subcortical extravasations are to be avoided as they should be (Fig. 158). The field of cortex as finally exposed reaches, as a rule, slightly above the Sylvian fissure, which is easily identified by its large veins (Fig. 159).

One must not forget that in the course of a decompression, though it be primarily a palliative measure, much of value for purposes of subsequent localization may be learned from the appearance of the exposed cortex, the position of the vessels, the conditions disclosed by palpation, and the presence or absence of fluid in the arachnoid spaces or ventricles. For example, if the Sylvian fissure is pushed upward with obvious broadening of the three temporal gyri, one may be fairly confident of an underlying lesion for, be it remembered, the operation is chiefly performed for unlocalizable tumors and as the defect is purposely made over the temporal convolutions for the reason that this is a relatively silent area, a tumor may not infrequently be found. In our

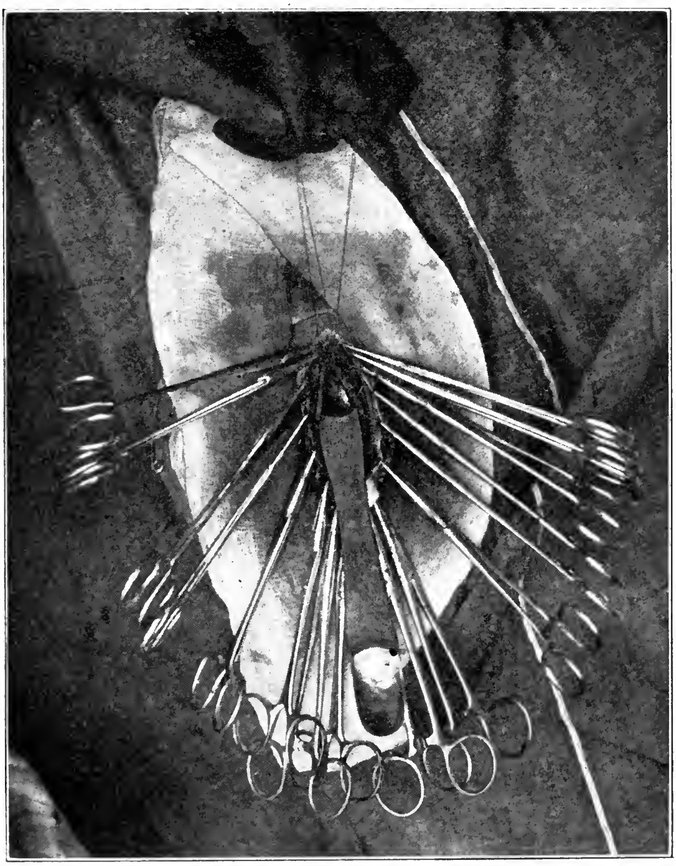


FIG. 162.—First stage of closure. Brain protected by spoon.

series of possibly 200 decompressions for unlocalized tumors, in at least fifteen instances we have unexpectedly come down upon the lesion. In some cases it has proved to be a gliomatous cyst and in others a solid tumor which has required for removal a subsequent osteoplastic operation in order to expose a wider area of the hemisphere. Four of our large series of successfully removed endotheliomas were first accidentally disclosed in the Sylvian angle in the course of a subtemporal decompression.

Careful palpation of the brain may enable one with experience to detect the peculiar cortical softness produced by a subjacent gliomatous cyst not uncommon in the temporal lobe, and the characteristic elasticity of the lobe associated with an internal hydrocephalus is often recognizable. A wet arachnoid or a dilated ventricle indicates that a tumor, at least one of any considerable size, does not lie in the exposed hemisphere. For this reason a ventricular puncture into the tip of the temporal horn is an important step of the procedure. With experience

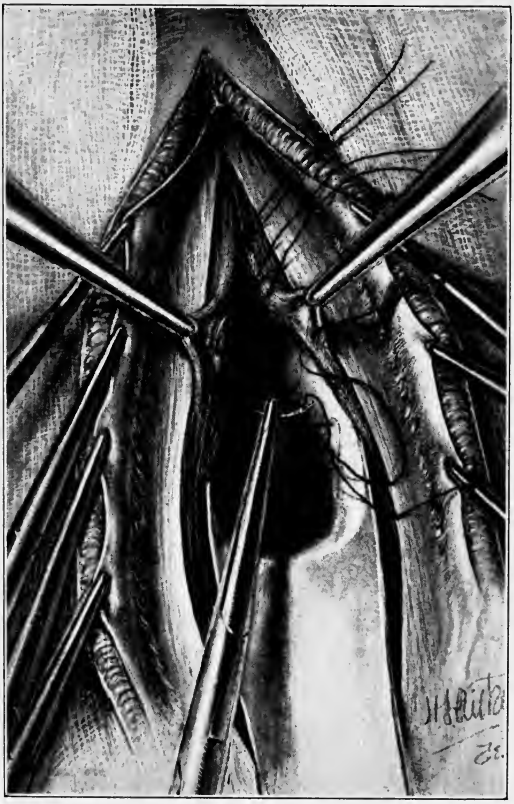


Fig. 163.—Showing placement of lowest layer of sutures at inner edge of muscle. (Natural size.)

and a good visualization of the ventricles, the hollow and slightly curved exploratory needle may be introduced into the temporal horn through the second or third gyrus (Fig. 160) without fail if the ventricle is dilated, and in about half of the cases if it is not. If a dilated ventricle is entered, on escape of the fluid the protrusion immediately collapses and all subsequent difficulties of closure are avoided. We have come to place so much importance on this step that when exceptional tension is encountered and there is fear of contusion of the lobe from excessive protrusion, the ventricle is tapped through a small nick in the dura over one of the lower convolutions before the membrane is incised.

It may be emphasized again that all possible cortical contusions and extravasations should be scrupulously avoided, for they merely add to preëxisting tension and if this is considerable there may be great

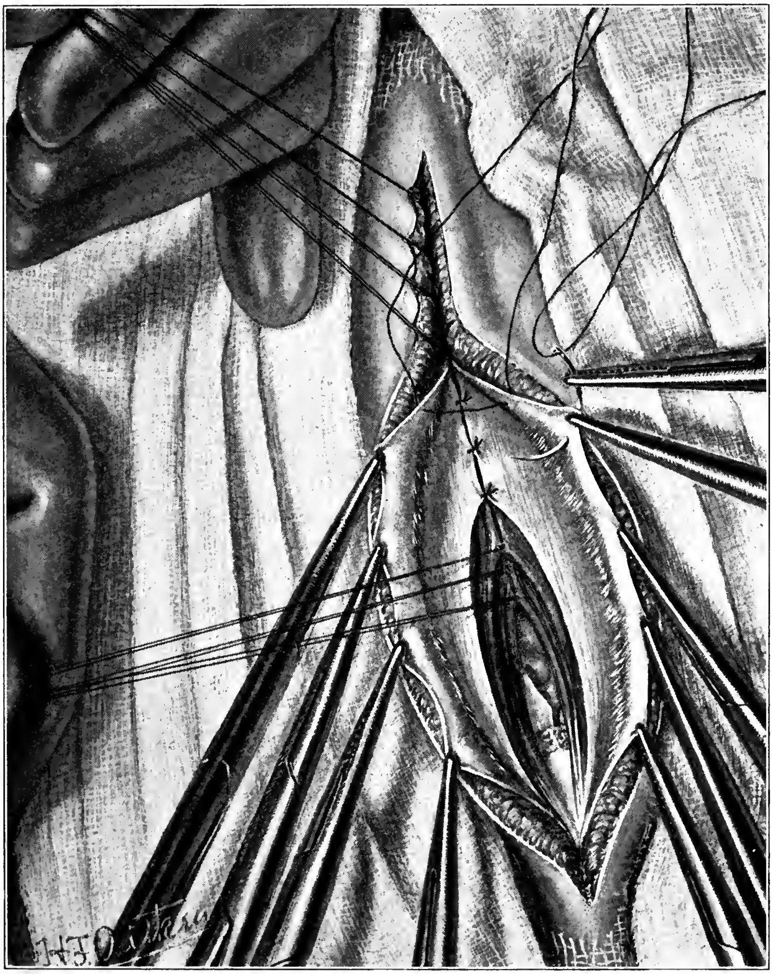


Fig. 164.—Showing the partial closure of the successive layers with the first four galea sutures tied to relieve tension on the fascia.

difficulty in making a secure closure. Moreover, as the herniation progressively increases, unless relieved by the successful withdrawal of fluid from the ventricle or a chance cyst, no time is to be wasted after the dura is once fully opened.

D. **Closure.**—This should be in layers Fine silk sutures passed on French needles are preferred since any heavier material is likely to tear through and split the delicate fascial edge. The sutures are cut almost at the knot so that there is no reaction even though some thirty knots may be closely superimposed in the four or five buried layers of the incision (*cf.* Fig. 161).

If there is considerable protrusion of the denuded lobe this should be protected by the spoon (Fig. 162) while the first layer of sutures at the lower border of the incised muscle are being placed (Fig. 163). The

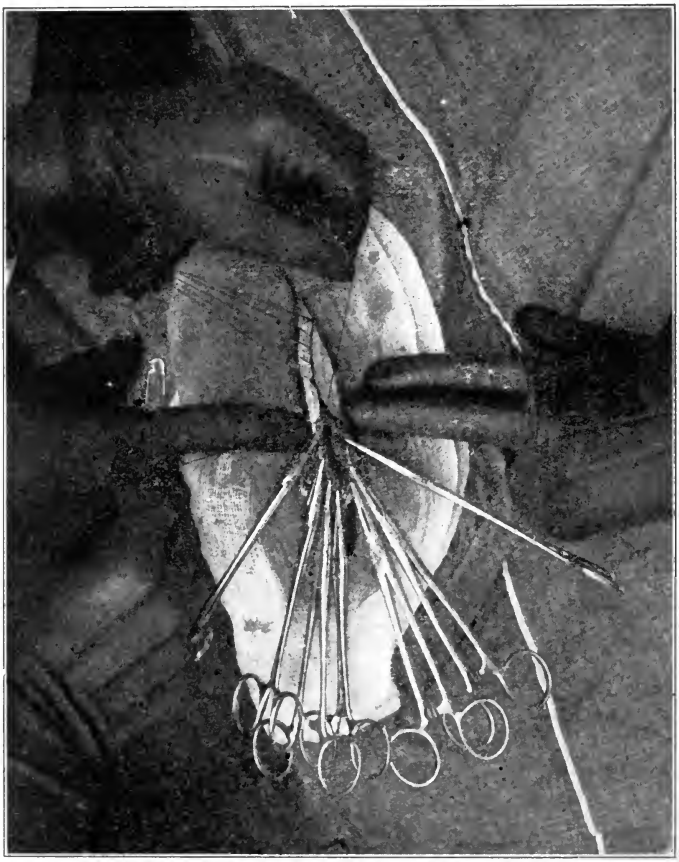


Fig. 165.—Further advance of closure, the scalp approximated by assistant's fingers, while tying galea sutures.

spoon is withdrawn as each successive suture is tied. The second layer of sutures is then placed in the outer edge of the incised muscle and not infrequently the edges of the inelastic fascia, which have been considerably stretched apart, may be coaxed together by two or three sutures placed as an extra layer in the loose subfascial connective tissue. The approximation of the fascial edges is the most difficult for the reasons given, and in most cases it is wise, in order to diminish the tension on the fascia, to place and tie one or two of the lower galea sutures. Thus the closure is partly completed in steps in its several layers (Fig. 164). The deeper layers are then closed through their whole length and the remaining galea sutures placed and tied as the clamps are removed (Fig. 165). As the suture material is very delicate,

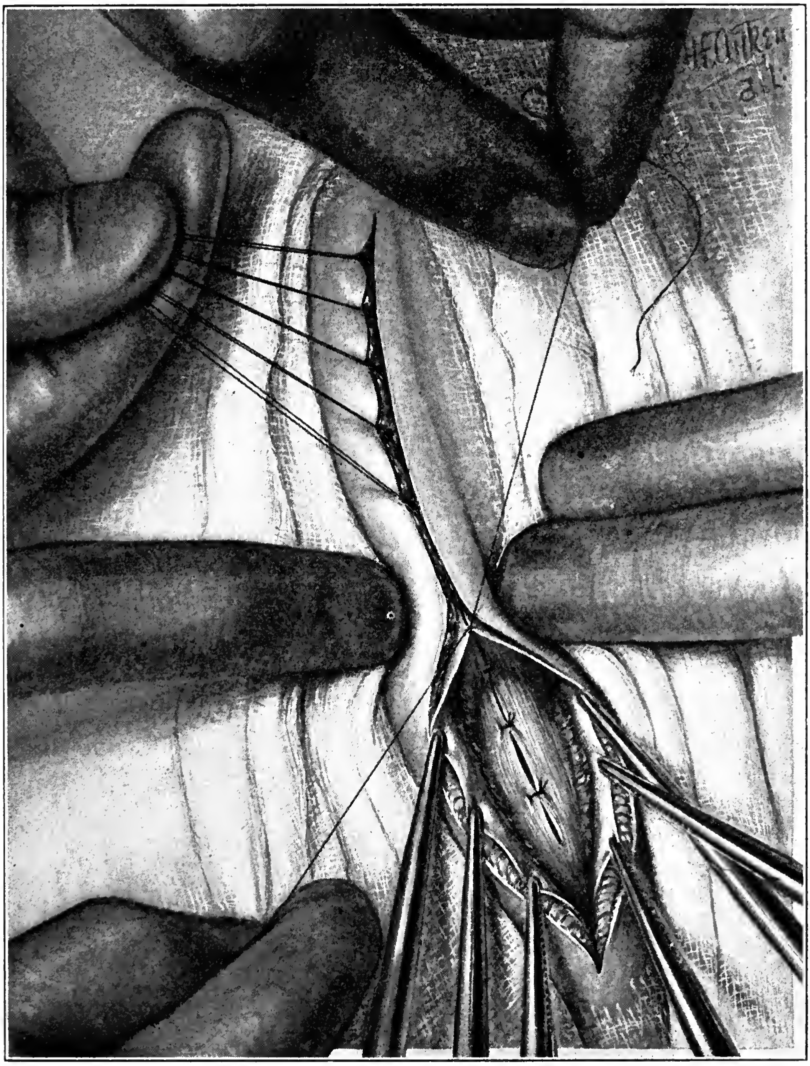


FIG. 166.—Detail of Fig. 165. Final closure of galea. (Natural size.)

the edges of the scalp should be approximated by pressure of the assistants' fingers (Fig. 166) to relieve strain on the sutures while tying. These galea sutures are then drawn taut so as to expose the knots close to which they are cut (Figs. 167 and 168).

There is no better way of closing the scalp incision than by the placement of a row of straight cambric needles which heap up and splint the tissue so that when the sutures are tied at the side an absolutely accurate edge-to-edge approximation of epithelium can be secured with flat wound surfaces so brought together as to prevent any oozing. (Figs. 169 and 170). Thus, aside from the silver clips on the dura, no ligature of vessels is required in the whole operation. These details may seem extravagant, but if they are not followed an occasional breakdown or leakage of fluid will inevitably occur.

FIG. 167.—Cutting of galea sutures at the knot.

The original sheets and towels are unpinned and unwrapped (Fig. 171), exposing the wound (Fig. 172), which is dressed preferably with silver foil. In applying the bandage, care should be taken to protect the ear from pressure lest it give discomfort; a starched roll is applied over all (Fig. 173).[1] The dressing should be removed and the scalp sutures cut after forty-eight hours, at which time a collodion gauze dressing

[1] To one unaccustomed to operating over the patient's head from the end of the table, these photographs may appear to be upside down, and the head to be hanging instead of slightly elevated. The camera was placed high and about in the line of the operator's vision.

may be applied, and at the end of a week the wound may be left without a support (Fig. 174). The incision should be practically invisible and with the hair trimmed there is little evidence of an operation having been performed except for the slight bulging which in the average case is not obtrusive (Fig. 175).

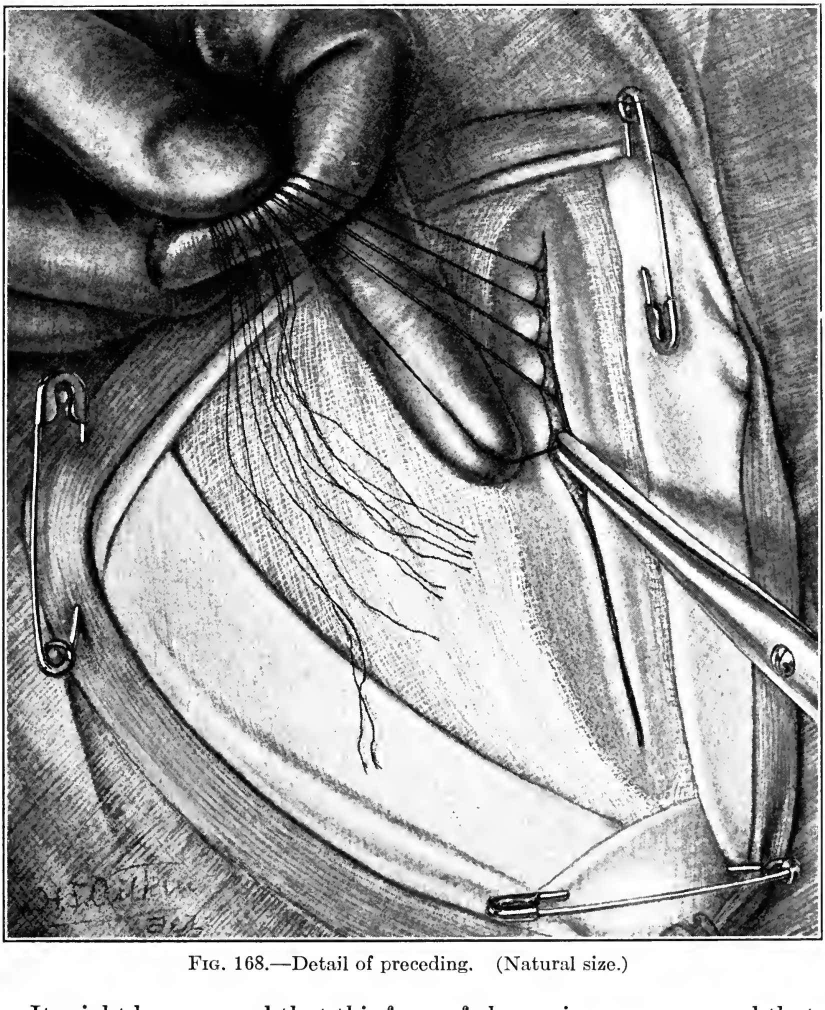


FIG. 168.—Detail of preceding. (Natural size.)

It might be supposed that this form of closure is oversecure and that by preventing a herniation it might combat the very ends for which the operation was undertaken. As a matter of fact, if the brain is tense the herniation gradually stretches the tissue so that the protrusion slowly enlarges, but there is no excessive protrusion and in the entire series of cases there has been no fungus cerebri or cerebrospinal fluid leak. The area of denudation is confined practically to the temporal lobe (Fig. 176) and no paralyses of any kind ensue even if there is considerable protrusion (*cf.* Figs. 177 to 180) My former fears that the auditory centers might be affected under these circumstances were without foundation. A fairly typical bone defect is shown in the *x*-ray (Fig. 181), though the lateral exposure fails to indicate the depth to which the defect is carried at the lower part of the temporal fossa.

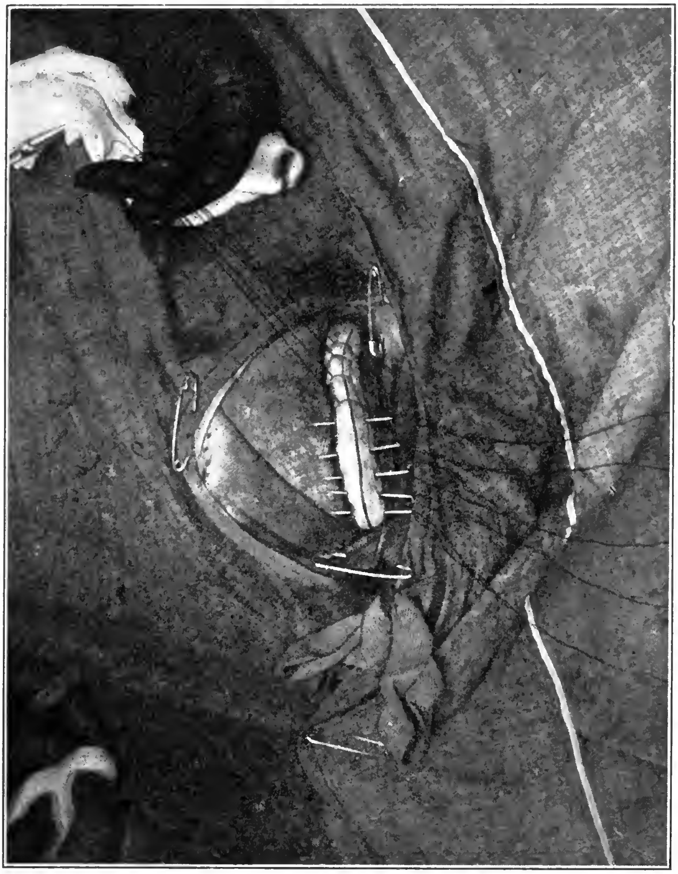


FIG. 169.—Superficial needles in place and partly tied.

To gain some idea of the conditions for which a subtemporal decompression may be performed, the following tabulation of the last 100 consecutive cases in the writer's series has been made.

1.	For unlocalized tumor presumably above tentorium	37
2.	For localizable but inaccessible tumor	23
3.	Provisional decompression before attempted tumor removal	6
4.	Decompression for multiple cerebral metastases	4
5.	For traumatic craniocerebral lesions associated with fracture of base	16
6.	For cerebral abscess simulating tumor	2
7.	For chronic serous arachnoiditis simulating tumor	4
8.	For cerebral syphilis with pressure symptoms	4
9.	For blastomycotic meningitis simulating tumor	2
10.	For thrombotic arteriosclerosis simulating tumor	1
11.	For otitic meningitis	1
		100

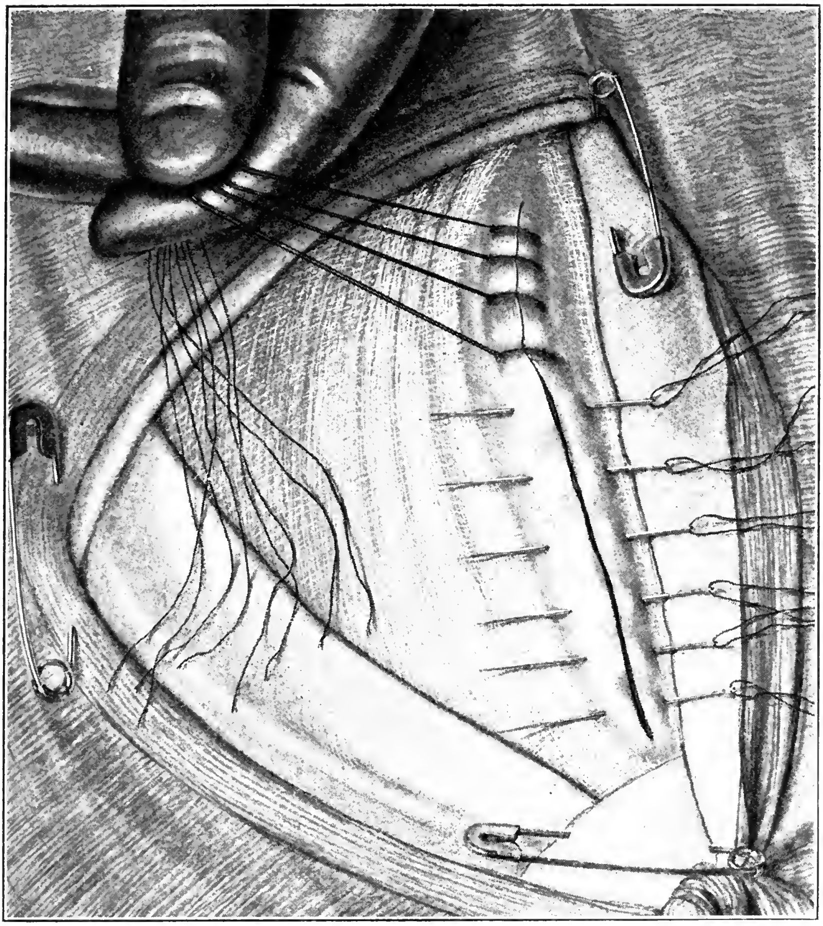


FIG. 170.—Detail of method of securing fine edge-to-edge approximation.

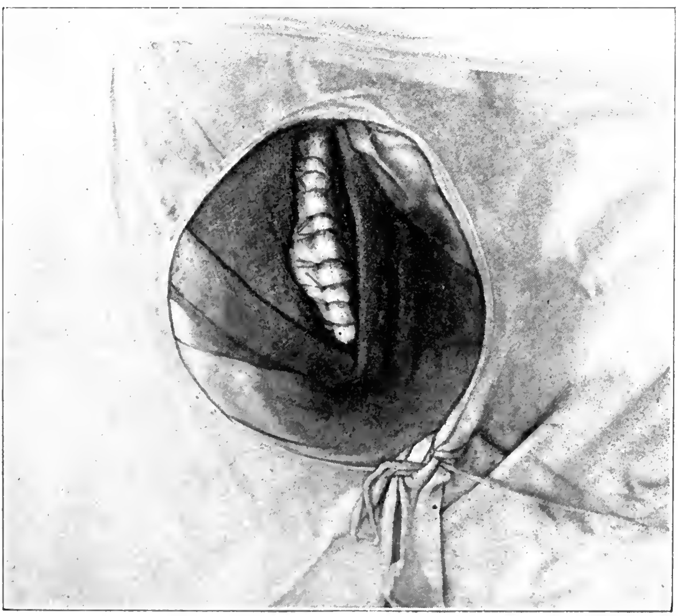


FIG. 171.—After removal of pins and outer gray sheet.

FIG. 172.—Exposure of sutured wound, before silver dressing.

FIG. 173.—Final starch dressing.

FIG. 174.—After six days, showing moderate bulging. Patient replaced on table and photographed in position of other figures.

FIG. 175.—Eighth day, showing moderate bulging. Patient holding up hair which otherwise would completely cover shaved area.

There were 6 deaths in the series which might be attributed to the operation, none of them, however, in the series of 70 true tumors of the first four groups, all of which were benefited in varying degrees. Death occurred soon after the operation in three of the acute fracture cases and the patient with extensive arteriosclerosis never recovered from the anesthetic. The torula meningitis cases likewise were unre-

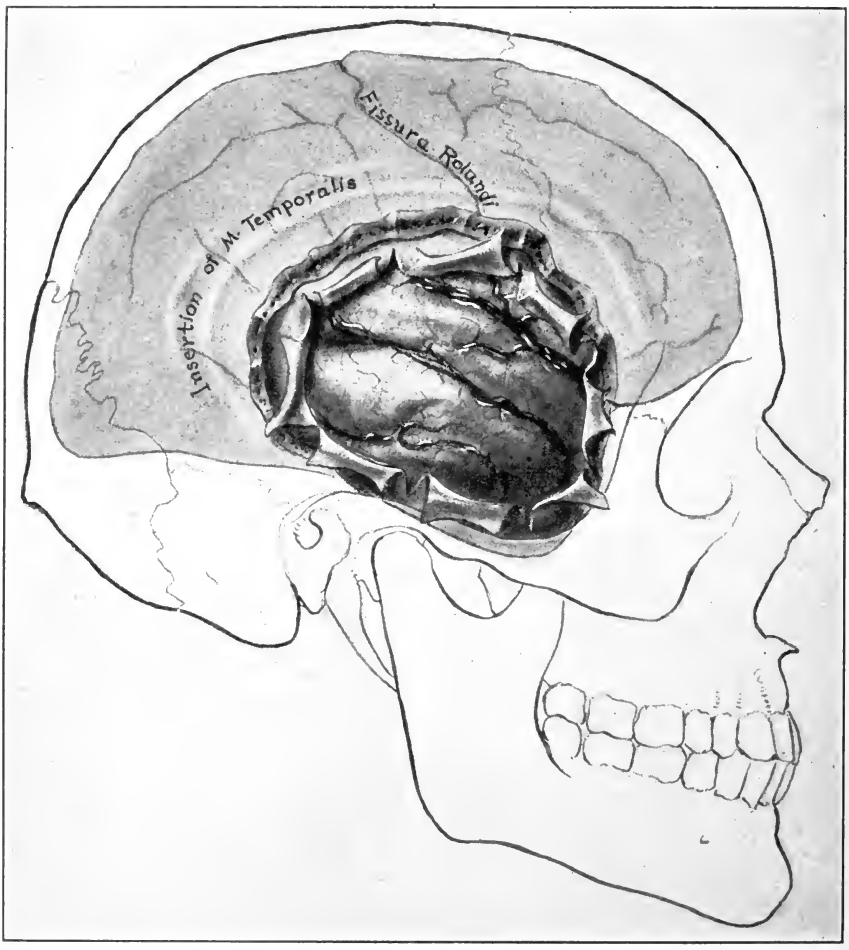


Fig. 176.—Diagram to show area of subcortical denudation in subtemporal decompression.

lieved though they survived for several weeks. The otitic case also succumbed. The growth has subsequently become localizable and since been operated upon in 7 of the 37 cases in the first group and doubtless this will be true of some of the remaining 30 as time passes. In 6 cases the tumor was disclosed in the temporal lobe at the time of the original decompression (three endotheliomas; three gliomatous cysts) and in 6 other cases a dilated ventricle was demonstrated, a matter of considerable localizing value as suggesting a posterior lesion.

This list of course does not include decompressive operations for tumors below the tentorium nor decompressive measures of other types which possibly should not be dismissed without a word of mention. A subtemporal decompression, though it may help in the diagnosis of

Fig. 177 Fig. 178

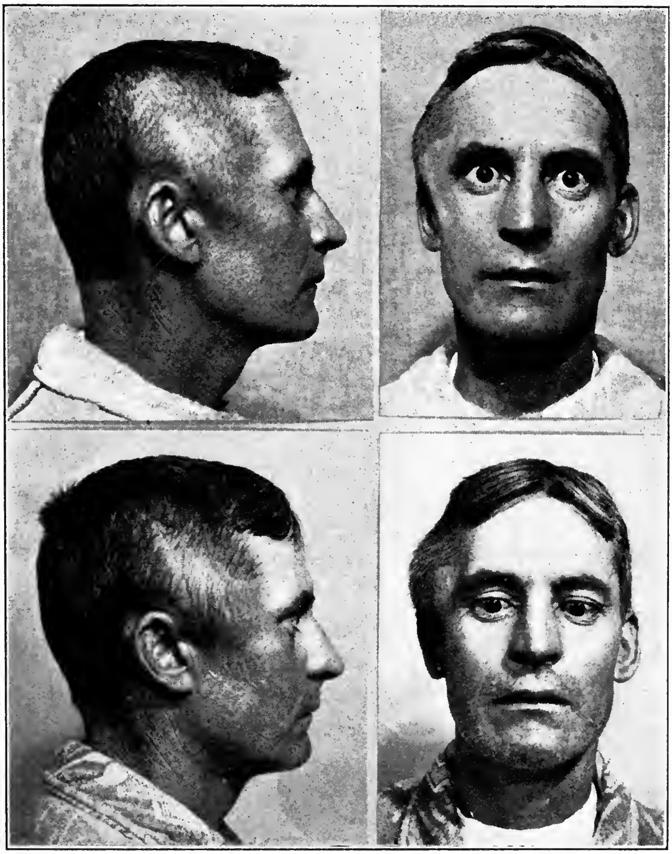


Fig. 179 Fig. 180

Figs. 177, 178, 179, 180.—Photographs taken on the tenth day and on the twenty-first day after a decompression disclosing an extensive temporal lobe glioma, with temporary complete relief of symptoms, to show secure healing and gradual increase of herniation despite the secure closure.

an obscure lesion by disclosing an internal hydrocephalus, does not greatly relieve the tension effects of a cerebellar tumor; and it may be added that no decompressive measure is of great avail in the case of pontine gliomas, for these lesions as a rule cause serious paralyses long before any marked pressure symptoms arise. Unmistakable subtentorial tumors, whether intra- or extracerebellar, should be approached with the purpose of attack at the first session and if they are not disclosed the suboccipital muscles and fasciæ should be closed in layers over the exposed cerebellar hemispheres, thus leaving the procedure as a decompressive measure.

Another and more complicated form of subtemporal decompression which often proves of great value, is one combined with an osteoplastic exploration.[1] Thus when under the reasonable expectation that a tumor will be found in one of the cerebral hemispheres, a bone flap

Fig. 181.—*X*-ray, showing average defect made in a subtemporal decompression. Note clips on vessels divided in dural incision.

has been reflected and the tumor not disclosed, it is the common practice to strip away the bone and close the scalp alone over the protruding brain. If there is so great tension that the intact flap cannot be replaced, there may be no other recourse, or if an inoperable glioma is exposed it is probably the wisest course to pursue. However, one always desires to replace a flap if it is possible or reasonable to do so, if for no other purpose than to prevent an undue protrusion of an undesir-

[1] Cushing, H.: Surg., Gynec. and Obst., 1908, ix, 1–5.

able area which may lead to contralateral palsies or accentuate those which were preëxistent. These ill effects may often be obviated by rongeuring away the area of bone which underlies the temporal muscle, not only from the reflected flap but also well down into the middle cranial fossa. The dura is then closed with the exception of the portion corresponding to this subtemporal defect and the flap replaced, leaving an opening in the skull in the same situation as that which would be made in the course of a subtemporal decompression conducted as a

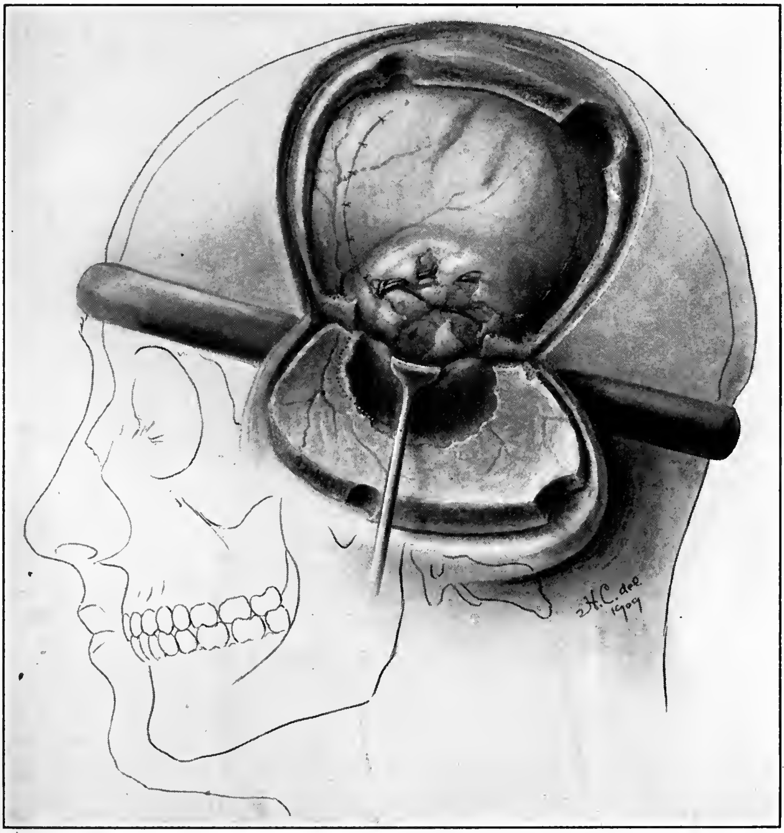


Fig. 182.—To illustrate a method of combining a subtemporal decompression after an osteoplastic exploration which has failed to reveal a suspected lesion.

primary measure (Fig. 182). Under these circumstances in the course of time, the osteoplastic flap may lift somewhat and add to the room gained by the subtemporal protrusion.

Another decompressive measure, which was originated by von Bramann,[1] is the so-called *Balkenstich* or callosal puncture highly recommended for cases with a secondary internal hydrocephalus due to

[1] Arch. f. klin. Chir., 1909, xc, 689.

posterior lesions which obstruct the cerebrospinal fluid. This measure, in the writer's experience, has been largely disappointing.

Thus there are various procedures which serve the purposes of decompression—namely, to furnish relief to the tension phenomena produced by tumors or other conditions. In the long run, however, the subtemporal operation is the simplest, safest and, for the average case, most satisfactory of all palliative surgical measures as yet suggested for tumors when they are either unlocalizable, or inaccessible, or when some temporary measure of relief is desirable to improve the condition of a patient who has a localizable tumor before the more critical osteoplastic procedure is attempted. The operation, furthermore, may be of diagnostic as well as of palliative value, as has been pointed out, for occasionally an unsuspected tumor is uncovered in the temporal lobe and not infrequently a puncture of the ventricle through the temporal convolutions will determine the presence of an obstructive hydrocephalus, a matter which may be of considerable localizing value.

SURGICAL COMPLICATIONS RESULTING FROM SUPPURATIVE MIDDLE-EAR DISEASE.

By GEORGE E. SHAMBAUGH, M.D.

Suppurative disease of the middle ear is a frequent source for serious intracranial disease, such as thrombosis of the lateral sinus, meningitis and brain abscess. These more serious complications develop, as a rule, as the sequel of disease of the mastoid process. It is important, therefore, that the surgeon should be familiar with the clinical symptoms of mastoid disease and with the surgical means for its relief. Mastoid disease occurring as a complication of an acute otitis media takes quite a different course and requires a different surgical treatment than when it occurs as a complication of chronic suppuration of the middle ear. For this reason the two conditions should be considered separately.

MASTOIDITIS IN ACUTE OTITIS MEDIA.

In order to understand the clinical significance of mastoid disease complicating an acute otitis media, it is necessary for one to have clearly in mind a few fundamental facts in the anatomy of the middle ear. The tympanic cavity is but one of a series of pneumatic spaces in the temporal bone which are included under the term of middle ear. The tympanum communicates with the nasopharynx by a canal called the Eustachian tube. It communicates also by means of an ample passage with a chamber of similar size located at the base of the mastoid process and known as the tympanic antrum. The communicating passage between the two chambers is usually referred to as the aditus. As a matter of fact, the tympanum with the aditus and the antrum constitute one large chamber, rather than three separate compartments. These chambers, with the Eustachian tube, exist at birth and constitute all there is of middle-ear cavities at that age. No mastoid process as such exists at that period. Before the child has reached maturity the mastoid process develops and as it develops its interior becomes honeycombed more or less throughout its entire extent by pneumatic cells which communicate through small canaliculi with the tympanic antrum. These pneumatic spaces in the mastoid process constitute a part of the so-called middle ear, just as do the tympanum with its antrum and the Eustachian tube.

Acute inflammation of the middle ear occurs for the most part as the result of infection from the nasopharynx, extending up through the Eustachian tube. It develops, therefore, as a rule, as the sequel of an acute pharyngitis, an acute tonsillitis or of an acute infection of the nasal chambers. An acute infection of the middle ear, acute otitis media, always involves the tympanic antrum as well as the tympanic cavity proper, since the two constitute one chamber with only a slightly constricted passage, the aditus, between them. On the other hand, the extension of the infection to the pneumatic spaces of the mastoid process is not a necessary complication of every acute otitis media. It occurs much more frequently, however, than the clinical symptoms over the process would indicate. Two facts must at all times be kept clearly in mind in the treatment of acute otitis media: (1) that mastoiditis with marked clinical symptoms occurs very frequently when surgical interference is not called for, and (2) that mastoiditis urgently requiring surgical interference often develops as a complication of acute otitis media when no outer evidence of this condition is apparent over the process. It is apparent, therefore, that the diagnosis as well as the surgical treatment of acute mastoiditis is by no means always a simple problem, but is often one which requires a careful study of the case if the proper treatment at the right time is to be carried out.

Symptoms.—Let us inquire now into the various clinical manifestations of mastoiditis and the indications which call for surgical interference. An acute otitis media which is complicated by an involvement of the pneumatic spaces of the mastoid, as a rule, develops distinct symptoms over this process. The first symptom is likely to be the development of pain over this region. This pain may be slight or it may become very severe, requiring a sedative if the patient is to get any sleep. The severity of the pain is more or less an indication of the severity of the reaction in the process, but is not in itself an indication for surgical interference except when it persists after the drum membrane has been opened and the drainage through the external canal freely established. The pain from mastoiditis is not always located over the process itself but not infrequently is referred to the temporal region of the same side. The persistence of pain in this region in connection with an acute otitis media should always be considered as significant as when it is centered more closely over the process itself.

Tenderness on pressure over the process is a very common symptom of acute mastoiditis. The degree to which the surface of the process becomes sensitive to pressure is, however, not always an indication of the character of the inflammatory changes taking place within. The surface of the process may be exquisitely sensitive in the early stages of an otitis media before the rupture of the membrana tympani, only to subside spontaneously a few days after the drainage of the tympanum has been established. Tenderness which persists, however, for more than a week after the drum-membrane has been opened or especially when it develops a week or more after the ear has begun to discharge, is much more significant of the presence of changes in the mastoid requiring surgical treatment than when this symptom develops in the early stages of the otitis media. Tenderness on pressure over the mastoid is located, as a rule, over the antrum, that is, close to the attachment of the auricle, just behind and above the external meatus or at the tip of the process, where especially large pneumatic spaces are often located. The complete absence of tenderness over the mastoid is no indication that the mastoid is not diseased. Indeed, it is very common to find a large abscess cavity in the mastoid process in cases in which at no time was there any evidence of tenderness on pressure.

Changes in the soft structure over the process have, on the whole, about the same significance as has the symptom of tenderness on pressure. When these changes, such as slight swelling and edema, develop in the earliest stages of the otitis media, we are justified in attaching much less significance to them than when they develop later, that is, after the ear has begun to discharge for a week or more. Edema and swelling developing over the mastoid before the drum-membrane has been opened disappears very often within a few days after the ear begins to discharge, and in these cases the mastoiditis usually goes on to spontaneous recovery. On the other hand, changes in the soft structures which persist for a week or more after the ear has begun to drain or where these changes develop after the drainage has been established, as a rule, indicate a softening of the mastoid bone, which calls for surgical interference. We would emphasize again the fact that serious disease in the mastoid process develops not infrequently with the formation of an abscess cavity, constituting a serious menace to the life of the patient through the development of intracranial complications in cases in which no changes in the soft structures over the mastoid ever appear. As a matter of fact the development of changes over the mastoid can even be regarded often as an indication of a less dangerous type of mastoid disease, in so far as it shows a tendency for the abscess to open externally rather than to burrow toward the brain cavity. Serious intracranial complications, however, may develop simultaneously with the occurrence of a spontaneous rupture through the cortex of the mastoid. A fluctuation of the swelling over the process indicates a perforation of the mastoid cortex and the development of a subperiosteal abscess, a condition rarely allowed to occur in these days except in young children, in whom the existence of a petrosquamosal suture through the antrum allows a ready extension of infection to the outer surface of the process. The best way to detect the early evidence of changes in the soft structures over the mastoid is by comparing carefully the two sides. The first evidence of such change will be the obliteration of the slight depression which marks the line of attachment of the auricle. It is only by comparing the two sides that one can recognize the first evidence of obliteration of this furrow. Swelling occurring in the neck below the tip of the process is not uncommon in adults and signifies the rupture of a mastoid abscess on the undersurface of the mastoid beneath the attachment of the sternomastoid muscle or the rupture of a pneumatic cell located internal to the digastric groove. The occurrence of such swelling in the neck always constitutes an indication for a mastoid operation.

Changes frequently occur in the external canal which give a clear indication of the conditions developing within the mastoid. The most significant is a distinct sinking in the soft structures along the upper posterior wall of the bony meatus, that is, in the depth of the canal just external to the drum-membrane. This part of the external canal is encroached upon (1) by the tympanic antrum and (2) by the pneumatic cells of the mastoid. A swelling along the upper posterior wall of the external meatus in the depth of the canal has exactly the same significance as the development of similar changes over the surface of the mastoid. It indicates, as a rule, the development of a softening of the bone and the formation of a mastoid abscess, a condition which requires surgical interference. A distinct narrowing of the fundus of the external meatus should always be regarded as an indication of a mastoid disease, which is pretty sure to require surgical treatment.

The development of a furuncle in the external canal from the infection of hair follicles by pus coming from the middle ear is not at all uncommon and should not be confused with a swelling occurring as the result of a periostitis secondary to a mastoid softening. The furuncle develops in the outer part of the canal, whereas the periostitis from a mastoid abscess develops in the depths of the canal. The location of the furuncle is usually below and in front, whereas the periostitis is always along the upper and posterior wall of the canal.

The development of a contraction in the opening made in the drum-membrane, associated with a more or less pronounced bulging of the upper posterior quadrant, has relatively little clinical significance. Enlarging the opening gives but a little temporary gain, as invariably within a day or two the original condition has returned.

An examination of the discharge from the external canal is often of great value in determining the condition within the mastoid. A profuse discharge, at first serosanguineous but later distinctly purulent and lasting from a few days to a couple of weeks, is the rule in uncomplicated cases of otitis media. When a profuse discharge continues, with no evidence of abatement in spite of proper treatment for a period of three weeks or more, it is distinctly significant of a condition within the process which should have surgical attention, provided this discharge is purulent in character as distinguished from a mucopurulent discharge. We are not able to attach so much importance to the bacterial examination of this discharge. One fact stands out distinctly, namely, that the cases which result in softening of the bone, that is, the cases which are most likely to result in serious complications and the ones which require surgical interference, are those in which the streptococcus is the prevailing organism. We do not feel that the bacteriological findings alone can give us positive indication for or against a mastoid operation.

Aside from subjective and objective symptoms of mastoiditis one usually gets some assistance from an examination of the temperature chart and the blood analysis in determining the seriousness of the mastoid disease. The temperature in an uncomplicated case of acute otitis media is much higher in children than in an adult. In the latter, before the rupture of the drum-membrane, it rarely goes above 101° or at most 102° F., whereas in children it ranges usually 1° or 2° higher. After the ear has begun to discharge there is, as a rule, a decided drop, even in cases in which the mastoid is more or less severely involved. In children this drop is not so marked as in the adult, and the temperature often reaches 102° for several days, or even a week or two, in cases which go on to a spontaneous recovery. On the other hand the tendency for the temperature to remain up for a week or more after drainage has been established, especially when, after a temporary decline, it shows a tendency to go up after the ear has been discharging for a week or more, should always be regarded as suspicious of a condition which will eventually require surgical assistance. On the other hand, in adults, especially, it is not uncommon for the temperature to show very slight elevation above normal in cases in which a distinct mastoid abscess is forming. Every case of acute otitis media in adults in which a temperature as slight as 99° persists for several weeks after the ear has begun to drain should be regarded with suspicion. Even this slight elevation may not be noted except at intervals of two or three days in cases in which a large mastoid softening is discovered at the operation. A chill followed by a sudden rise in temperature, occurring in a case in which the drainage through the drum-membrane has been established, is always on ominous sign, for it rarely occurs in cases which do not require operation.

As regards the blood examination the increase in the white count after the ear has begun to discharge is not very marked, especially in adults, even with the development of mastoid abscess. The white count usually does not go above 10,000 to 12,000. A much higher white count is rather significant. It is found in cases in which the mastoid abscess has ruptured through the cortex, producing an involvement of the soft structures, or into the tissues of the neck. An involvement of the lateral sinus is usually heralded by a marked increase in the white count.

Diagnosis.—Additional information of the condition within the mastoid in an adult can be gathered by transillumination of the process and by examination of a skiagraph. Transillumination is carried out by introducing a small lamp into the external canal. If the pneumatic cells of the mastoid are filled with pus a distinct shadow will be noted which is not found on the opposite normal side. This shadow is not in itself an indication that a condition exists in the mastoid requiring an operation. Mastoiditis with pus filling the mastoid cells is a frequent complication of an acute otitis media, whereas relatively few of such cases require a mastoid operation. It is only when the bony structure undergoes softening with the formation of a mastoid abscess or when symptoms occur suggesting an intracranial complication, such, for example, as a chill with high temperature or a persistent severe pain that an operation is required. As a matter of fact, transillumination gives us no clue for differentiating between a mastoiditis with cells filled with pus and a mastoiditis with breaking down of bone. It is indeed the exceptional case in which transillumination gives any information of the condition within the mastoid that we cannot gain by an analysis of the subjective and objective symptoms discussed above.

The skiagraph properly made is often able to show just the differentiation we desire between a mastoid process filled with pus and one where an abscess cavity is forming. A cloudy mastoid has, as a rule, no more significance than the shadow found on transillumination, and is not in itself an indication that a disease exists requiring surgical interference. On the other hand a well-made skiagraph will often show very clearly the presence of softening bone and formation of a mastoid abscess in just those cases in which the physical changes over the process fail to give a satisfactory clue to the true condition going on in the process.

From this discussion of the symptomatology of acute otitis media and of acute mastoiditis it is at once apparent that the diagnosis of the condition existing in the mastoid, and especially the decision of when the mastoid operation should be performed, often requires a careful exhaustive examination of the case.

If we should attempt to summarize in a few words the indications for mastoid operation in acute otitis media, we would state that matter somewhat as follows:

1. When distinct symptoms of a mastoiditis such as pain and tenderness over the process persist without evidence of abatement for a week or more after the drum-membrane has been opened and free drainage established.

2. When symptoms develop suggesting an impending intracranial complication, such as the persistence of severe mastoid pain or the occurrence of a chill and high temperature.

3. When a swelling develops over the mastoid, pushing the auricle forward, or when a swelling develops in the neck below the tip of the mastoid.

4. When a distinct sagging of the upper posterior wall of the external meatus takes place.

5. The continuation of a profuse purulent discharge for three weeks or more after the drum-membrane has been opened and proper treatment carried out.

6. When the skiagraph shows distinct area of softening in the mastoid process.

Treatment.—The earliest operation for the relief of acute mastoiditis consisted of making a long incision through the postauricular swelling cutting through the periosteum. This method of operating is now discarded except occasionally in young children. Later the method of making an opening into the antrum was introduced. This operation was based on the idea that the antrum was the principal seat of the trouble and that the condition was most quickly corrected by draining the antrum. As a matter of fact, it is not the infection in the antrum any more than of the tympanum proper that constitutes a mastoiditis, but the infection in the mastoid cells. While it is true that by making an opening through the cortex into the antrum a degree of drainage is established for the infected mastoid cells, a better method is to attack directly these infected cells. The actual opening into the antrum may be omitted with no distinct disadvantage in many cases. The modern mastoid operation for acute mastoiditis aims at as complete an exenteration of the infected mastoid cells as is possible. When this has been accomplished and all softened bone removed from the mastoid the case is pretty sure to make a good recovery.

A glance at the several types of mastoid processes shows how different this operation must be in different cases. In the pneumatic type, where the whole process is filled with air cells (Fig. 183), the exenteration

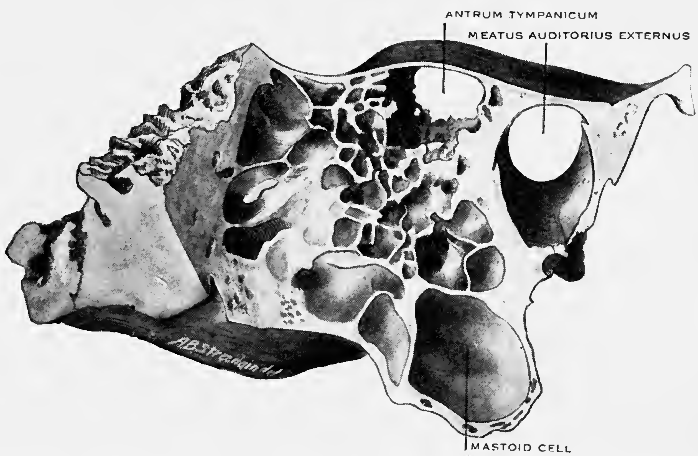


FIG. 183.—Section through pneumatic type of mastoid, showing the large cells along the periphery of the process and at the tip, also the position of the antrum above and posterior to the external auditory canal.

is more easily accomplished than in the type where a part of the process remains diploetic (Fig. 184). The cells that are most readily overlooked are those which lie outside the confines of the mastoid process proper, such as the large cell which sometimes develops internal to the digastric groove (Fig. 185), the cells in the root of the zygoma above the external canal, and the cells which develop along the posterior margin of the mastoid process, and especially the cells at the upper posterior angle An incomplete operation on the mastoid, leaving the deep-seated infected cells unopened, is a frequent cause for a persistent discharge from an unhealed wound and for the development of fatal intracranial complications. It behooves the surgeon, therefore, who undertakes the operation for the relief of acute mastoiditis to make a careful study of the complicated anatomy of the temporal bone, in order that he may do this without injury to the important anatomical structures which come into close relation with the mastoid, such as the lateral sinus, the facial nerve and the horizontal semicircular canal.

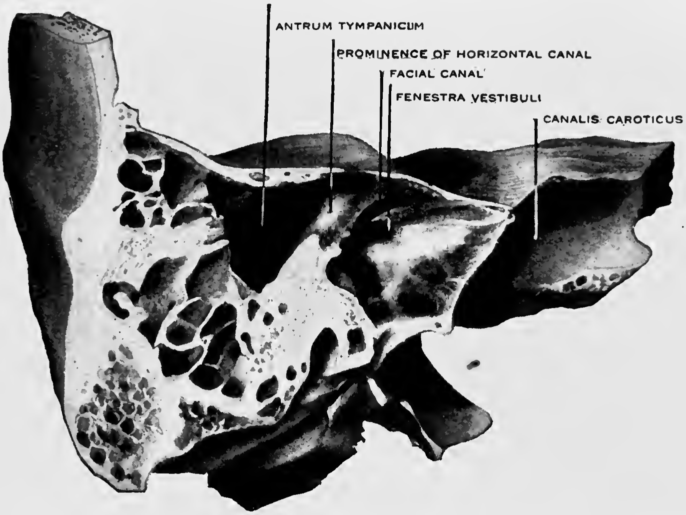


Fig. 184.—Section through mastoid process and tympanum; mastoid process showing but few air spaces.

In performing the mastoid operation the safest instruments have been found to be the gouge, bone forceps and the curette. Because of the variation in the course of the lateral sinus, the removal of the outer

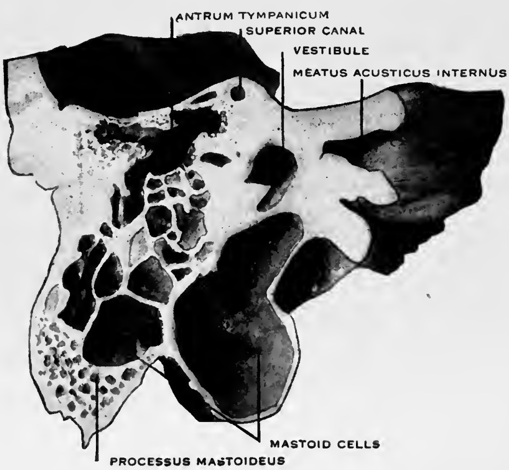


Fig. 185.—Section through temporal bone, showing a large pneumatic cell internal to digastric groove.

shell of the mastoid must always be undertaken with great caution. As a rule the sinus is located fully one-half inch from the surface of the mastoid and three-fourths of an inch back of the posterior wall of the external canal, yet it is not uncommon to find the sinus pushed far forward, so that it lies but a few millimeters from the external canal and close under the outer surface of the mastoid. The first step in the operation is the complete removal in thin layers of the outer shell of the process by using the gouge held quite flat to the surface of the bone. After this is accomplished one penetrates into the deeper parts of the mastoid in the same cautious manner until the outlines of the lateral sinus are clearly exposed. The sinus is easily recognized by the more dense character of its bony covering. The antrum is found by working in the depth along the upper posterior wall of the external meatus. It is not safe to penetrate too deeply in this region, for if one fails to differentiate the antrum from a large mastoid cell and attempts to penetrate still deeper the first cut of the chisel in the floor of the antrum may open into the labyrinth, since the horizontal semicircular canal forms the floor of this cavity (Fig. 2). It is at this point, too, where the greatest danger of wounding the facial nerve lies, since the facial canal lies exposed to injury just in front of the horizontal canal. The facial canal passes along the posterior wall of the external meatus, on the level of the tympanic cavity, to emerge through the stylomastoid opening. It is possible to injure the facial nerve even in doing the simple mastoid operation if the operator is not thoroughly familiar with its course through the temporal bone.

It is not our practice to leave the mastoid wound wide open and packed firmly with gauze, as was formerly done. The wound is brought together both above and below and through a rather small opening about the middle of the incision a loose drain is inserted. Ample outer dressing is then applied. The latter should be changed as rapidly as it becomes soaked. The gauze drain need not be disturbed for five or six days, unless, from a rise in the temperature, it is suspected that proper drainage is being impaired. With this method it requires from three to six weeks for the wound to close. Should a rather profuse purulent discharge continue longer than a month after the operation it suggests the probability of further extension of the bone disease in the depth of the opening, which may require exenteration.

MASTOID DISEASE IN CHRONIC SUPPURATIVE OTITIS MEDIA.

Mastoid disease complicating chronic suppurative otitis media presents problems quite different from those of mastoiditis occurring in connection with acute otitis media. The menace from serious intracranial disease, such as brain abscess, meningitis and sinus thrombosis, is, perhaps, even greater than in acute middle-ear infection. The selection of the cases of chronic suppurative otitis media, which are a menace from the more frequent but relatively harmless cases, and the cure of the former by proper surgical measures, constitutes one of the greatest achievements of modern otology. There was a time when it was considered dangerous to undertake the cure of chronic discharge of the ear, the idea being that this discharge constitutes a means for the escape of poisonous material, the checking of which was likely to bring on some intracranial trouble. When it became known that a large percentage of chronic brain abscesses, not to mention cases of meningitis and of sinus thrombosis, developed as a sequel to an apparently harmless chronic running ear, efforts were made to accomplish the cure of these cases by surgical measures. It was soon found that the type of operation which sufficed to cure the mastoid complications of acute otitis media would not cure cases of chronic otitis media. Otologists finally elaborated a type of operation which would cure such cases. The working out of this problem, as well as the clinical differentiation of the cases of chronic otitis media from which complications were imminent from the relatively harmless cases of chronic middle-ear disease, constitutes one of the best examples of the results to be obtained by concentration of effort, which is only possible through the modern method of specialization in medicine. The solution of the first problem was accomplished through the elaboration of the so-called radical mastoid operation. The solution of the second problem, the selection of cases requiring surgical treatment, is a more recent achievement. There was a period after the radical mastoid operation had been perfected when this operation was considered indicated for all cases of chronic suppurative otitis media which could not be cured in a reasonably short period by local measures applied to the tympanum. At present the continuation of discharge from the middle ear is not the criterion determining whether the case should be subjected to an operation. Many cases of chronic otitis media are relatively harmless affairs from which serious complications need not be feared. So long as the disease involves only the mucous membrane lining the middle-ear chambers no complications are likely to develop. In this respect chronic otitis media is not unlike acute disease. It is only when the process begins to invade the temporal bone that the possibility of a serious complication arises. As a matter of fact the transition from the simple to the dangerous type rarely takes place after the disease has once become chronic. The invasion of the bone usually, if not always, begins during the early acute stages of the otitis media, and for the most part such cases represent those which should have had the simple mastoid operation performed during the acute period at the onset of the otitis media. For just these reasons the practice of operating all cases of chronic suppurative otitis media which could not be cured in a short period by local means, as a prophylactic measure, has now been discarded. The operation is reserved for those cases in which an involvement of the bone can be diagnosed.

Diagnosis.—The diagnosis of a bone-invading process in chronic suppurative otitis media can usually be accurately determined by a careful study of the case. Most important in making this diagnosis is the character of the discharge from the middle ear. The discharge that is found in a case in which the mastoid bone is diseased has usually a peculiarly offensive odor. The discharge from any chronic running ear which has been neglected and which has not received proper local treatment is likely to be more or less foul. In the simple cases, those in which the bone is not diseased, this odor promptly disappears under simple cleansing treatment with antiseptic solutions. Not so the cases complicated by disease of the bone. Here the odor usually persists in spite of the most scrupulous local treatment.

The amount of the discharge is not an essential element, although the more active the disease process the greater is likely to be the discharge. Serious intracranial complications frequently occur in cases in which the discharge is so slight that the patient may not be aware that he has had a running ear for many years. When wiping out the tympanum with a pledget of cotton in such cases only a few strands of the cotton may show any moisture. In such cases the odor on the cotton swab can be detected more readily than can the actual presence of moisture. In other cases the fundus of the canal appears quite dry, but a dry crust is found adherent, especially along the upper wall of the canal, the undersurface of which is found to be moist and with the characteristic odor of secretion from bone disease.

A mucousy discharge from the ear, no matter how profuse, is not found in connection with a bone-invading process except as it may occasionally be caused by a temporary acute exacerbation involving the mucous membrane of the middle ear in cases in which there already exists a chronic bone-invading process in the mastoid. The discharge from a disease of the bone is granular in character, as distinguished from the more mucousy discharge found in the simple cases. This character of the discharge can be determined by examining the cotton swab after wiping out the external canal, but is more readily recognized by examining the washings after irrigation.

An important clue in the diagnosis of these cases can be obtained by a careful examination of the fundus of the external canal. When an invasion of the bone is going on the perforation of the drum-membrane is almost without exception marginal in character and is located in the upper posterior quadrant, with a distinct erosion of the bony canal in this location. Another, though less frequent, location is in Shrapnell's membrane, at the upper pole of the drum-membrane. The marginal perforation may rarely be located in the anterior part of the membrane. The size of the perforation has very little significance. A practically complete destruction of the membrane is found in a large percentage of the harmless cases of chronic suppurative otitis media.

The presence of granulations and polyp formations in the fundus of the canal has not the serious significance that has often been attributed to it. It is only when there is a tendency for these conditions to recur, and especially when they are associated with other evidences of a bone-invading process, that they have a special significance.

A cholesteatomatous formation complicates a large percentage of the cases in which the temporal bone is involved. This condition develops only when a marginal perforation in the drum-membrane exists. A central perforation, no matter how large, is never complicated by an invasion of the middle-ear cavities with epidermis from the external canal and the formation of a cholesteatoma. The existence of a cholesteatoma can be diagnosed, as a rule, with but little difficulty by the detection of the characteristic whitish flakes in the fundus of the canal and especially in the washings after irrigation. The existence of a cholesteatoma constitutes the chief menace in most of the more dangerous cases of chronic suppurative otitis media. The antrum and aditus, as well as the attic, become filled with the material, which, by exfoliation of the surface membrane, constantly increases in size and produces by its pressure a constant erosion of the cavity walls until some vital structure is perforated. If this perforation takes place in the horizontal canal in the floor of the antrum it leads usually to a destruction of the labyrinth. When the wall of the lateral sinus is invaded, sinus thrombosis results. If the process causes an erosion of the roof of the antrum it leads eventually to a fatal meningitis or an abscess of the temporosphenoidal lobe.

Subjectively, the patient has, as a rule, no symptom, even in cases in which the bone is being invaded, except when an acute exacerbation of the chronic process sets up an acute otitis media. Aside from these cases, pain, indefinitely located but restricted to the affected side of the head, is sometimes observed, and when present is quite significant. Its complete absence does not by any means exclude the possibility of a dangerous disease in the mastoid.

Treatment.—The indications for a radical mastoid operation in cases of chronic suppurative otitis media are restricted to those cases in which an examination discloses evidences of a cholesteatoma or of bone-invading disease. In addition should, of course, be included those cases in which an acute exacerbation brings on symptoms of an acute mastoiditis as well as the cases presenting symptoms of an intracranial complication.

The radical mastoid operation is a much more difficult undertaking than is the simple mastoidectomy which is performed for the cure of the mastoiditis complicating acute otitis media. It is important before undertaking this operation to bear in mind the fact that in chronic suppurative otitis media requiring a radical mastoid operation no pneumatic mastoid process exists, the reason being that in most cases the suppurative middle-ear disease begins in early childhood before the pneumatization of the mastoid has taken place and the disease in the antrum prevented the normal development of mastoid cells. In other cases in which the otitis media began after the process had become pneumatic, by a slow process of osteosclerosis these cells have become obliterated. All that exists of the middle-ear chambers in these cases is the tympanum with its attic and the tympanic antrum. The latter, as a rule, is a much contracted chamber. The simple opening and cleaning out of the antrum will not suffice to cure these chronic cases, because the disease process also involves the aditus as well as the attic. The radical mastoid operation consists of an exenteration not alone of the antrum but of the aditus and attic, as well as of the tympanum and the tympanic orifice of the Eustachian tube, followed by a plastic, which aims to secure an epidermization of the common chamber made of these cavities.

The first step is to secure an opening into the antrum. This, because of the usually contracted size of the cavity and the sclerosed mastoid bone through which the opening has to be made, is a difficult, painstaking procedure. With the bony meatus freely exposed and the location of the antrum just above and behind the wall of the canal in mind the opening of the antrum is accomplished by making a funnel-shaped opening through the mastoid process with the apex always directed along the upper posterior bony meatus and the outer opening broad and flat. The next step after the antrum has been entered is to remove the posterior wall of the bony external meatus. This will serve to lay open the aditus. After that the outer wall of the attic is taken away, followed by a careful exenteration of the tympanic cavity and of the tympanic orifice of the Eustachian tube.

The operation should not be undertaken on the living without ample experience on the cadaver. There are a number of important anatomical structures that may readily be injured unless one is quite familiar with the technic of the operation and of the anatomical relations of the temporal bone. The danger of wounding the lateral sinus in making the opening into the antrum is the same as in performing the simple mastoid operation. It is after the antrum has been entered, however, that the chief danger of injuring important anatomical structures arises. It is important, therefore, that the outer opening into the antrum should be made ample so that one can see clearly the relations in the bottom of the opening. Because of the small size of the antrum it is a very easy matter to chisel too deeply and to chip off a piece in the floor of this cavity. Such a mistake will usually open directly into the labyrinth by breaking through the horizontal canal, which forms the bottom of the antrum as one enters this cavity through the mastoid process.

In removing the posterior wall of the bony meatus there is danger of injuring the facial nerve which courses down along the posterior margin of the tympanic cavity. At the level of the aditus this nerve lies on the same plane with the inner wall of the tympanum, but toward the floor of the tympanic cavity it courses out perceptibly along the posterior wall of the external canal. For this reason the posterior bony meatus must be removed with great care. On the level of the aditus the whole of the bony wall can be taken off, but as one approaches the floor of the tympanum more and more of a ridge must be preserved to protect the facial nerve from injury. The proper flattening of this facial ridge is one of the delicate parts of the mastoid operation. It is very important that as little of the ridge as possible, for the safety of the facial nerve, should be left standing (Fig. 5).

The removal of the outer wall of the attic is also fraught with danger to the facial nerve, as the canal for this nerve passed horizontally through the tympanum just internal to the free edge of the attic covering. In curetting out the tympanum, which has to be scrupulously done to get rid of all of the mucous membrane lining this chamber as well as of any diseased bone, caution must be observed not to disturb the stapes in the oval window. In curetting the floor of the tympanum one should not lose sight of the fact that the bulb of the jugular may lie exposed in this region or be covered by only a delicate bony shell (Fig. 186). Again, in curetting out the tympanic orifice of the Eustachian tube the close proximity of the internal carotid along the mesial aspect of this canal requires caution, lest the instrument breaks through its thin bony covering.

Fig. 186.—Section through temporal bone passing through external canal, tympanic cavity, and internal meatus, showing relation of jugular bulb to floor of tympanum.

The principle in making the plastic, the aim of which is to secure epidermization of the combined middle-ear cavities left after the completion of the bone work, is the splitting of the membranous external canal, making two flaps. The upper flap is pushed into the upper part of the bone cavity while the lower flap is approximated to the lower wall. Both flaps may be anchored with catgut sutures. From the external meatus a narrow strip of gauze is now introduced, which holds these flaps securely in place. The incision back of the ear is then brought together throughout its entire extent. The outer dressings should be removed as often as they become soiled, but the packing in the external canal should not be disturbed for about a week. The subsequent careful repacking with gauze strips, the cauterizing of the exuberant granulations, all require skill, in order to bring about the epidermization of the bony cavity. No exact period can be stated of the time required until the healing is complete, but, as a rule, very little attention is required after from three to six weeks.

COMPLICATIONS OF MASTOIDITIS.

The more serious complications of suppurative otitis media develop, as a rule, secondary to a mastoiditis, but they may also occur as the result of direct extension from disease in the tympanum in cases in which none of the clinical evidences of a mastoiditis exist.

Infectious Labyrinthitis.—Extension of infection to the internal ear is a complication of both the acute and chronic forms of suppurative otitis media. A marked depression of the function of hearing is usually one of the characteristic symptoms of such an extension. This depression of the hearing function is likely to prove the most serious symptom for the patient, as it frequently means a permanent loss of this important sense. The labyrinth of the ear includes the end-organs not alone

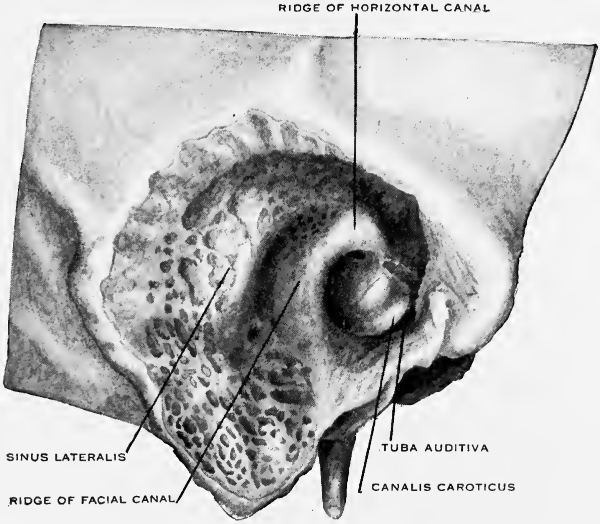


FIG. 187.—The appearance of the temporal bone after the bone-work for the radical mastoid operation has been completed.

of hearing but others which play an important part in preserving the body equilibrium. The symptom which causes the most immediate annoyance to the patient does not arise from the destruction of the hearing function, but comes from the disturbances of the end-organs of equilibrium. These end-organs are located in the semicircular canals and in the vestibule. Any sudden involvement of this mechanism, such as results from an extension of infection from suppurative otitis media, produces a violent attack of vertigo associated usually with intense nausea and vomiting. It is these symptoms of nausea, vomiting and vertigo that constitute the chief complaint of patients suffering from an acute labyrinthitis. Very little complaint is made of the impairing of hearing, especially when one ear remains normal, until later, when the vertigo subsides. The duration of the vertigo is always temporary, for even when it is caused by a complete destruction of the function of the internal ear it may not persist longer than a couple of weeks.

We cannot enter into a discussion of all the phenomena associated with an extension of infection to the internal ear. We aim rather to make such a statement of these symptoms that the surgeon may be able to recognize what he is dealing with. We speak of three types of infectious labyrinthitis complicating suppurative disease of the middle ear: a circumscribed labyrinthitis; a diffuse serous labyrinthitis; and a diffuse suppurative labyrinthitis.

The circumscribed form of labyrinthitis is a complication only of chronic mastoiditis. It is the result of an erosion of a bone-invading process through the capsule of the labyrinth. This erosion takes place usually in the horizontal canal, where this structure lies exposed in the floor of the aditus ad antrum. It may rarely penetrate the superior canal where this lies exposed on the inner wall of the aditus. The development of the fistula into the labyrinth is by a slow process of erosion of the bony capsule and results in an involvement of the membranous structures in the inner ear only in the immediate region of the bony fistula. Here the process becomes circumscribed, walled off from the remainder of the labyrinth by protective granulations. The infection may in rare cases eventually break through these granulations and give rise to a diffuse infection of the internal ear.

Very few symptoms are noted as long as the disease remains circumscribed to the region of the bony fistula. The presence of such a fistula can usually be readily diagnosed by making compression of air in the external meatus, either by means of a Politzer bag or even by pressing the finger in the external meatus. Such compressiom will cause a depression of the soft structures closing the opening in the bone and result in a movement of the endolymph in the semicircular canal. If the fistula is in the horizontal canal the eyes will be seen to move in the horizontal plane toward the opposite side and then jerk quickly back toward the affected side, thus producing a characteristic horizontal nystagmus. When suction is made in the external meatus this movement of the eye is reversed. Should the fistula be located in the superior canal, compression of air in the external meatus will produce a rotary nystagmus.

Diffuse labyrinthitis is a complication of the acute as well as of the chronic suppurative otitis media. It is a more serious complication not alone because of the danger of a permanent destruction of the function of hearing, but also because of the risk of an intracranial extension setting up a meningitis or a cerebellar abscess. The milder cases of diffuse labyrinthitis are the result of a serous disease of the internal ear, while the more severe cases are caused by a suppurative process invading the labyrinth. It is not always possible to make a sharp differentiation clinically between the serous and the suppurative processes. Of this, however, we may be sure: that any process which causes only a partial suppression of the function of the labyrinth, leaving either a remnant of hearing or of the function of the semicircular canals, is always the serous type of labyrinthitis. On the other hand a diffuse suppurative labyrinthitis always results in a complete and permanent destruction of the function of the labyrinth. Clinically it is of great importance to make this diagnosis between the serous and suppurative processes, because the suppurative form not infrequently leads to a fatal intracranial complication, which may be prevented by a timely operation providing adequate drainage for the infection in the internal ear, whereas the serous form rarely if ever produces such a complication. The diagnosis is not always possible for the reason that the more severe cases of serous labyrinthitis may produce a complete suppression of the function of hearing as well as of the semicircular canals. From the disturbances of function caused by the serous disease of the labyrinth it is always possible for a patient to make a complete recovery. The depression of function resulting from an acute invasion of the labyrinth, disturbs the normal equlilbrium and produces intense vertigo, and a rotary nystagmus with the quick movement of the eyes directed to the opposite side. This is always a temporary phenomenon, for even in cases in which, as a result of a diffuse suppurative labyrinthitis, there is a complete destruction of function in the affected ear the vertigo and nystagmus disappear usually within two or three weeks.

Treatment.—An operation on the labyrinth is undertaken to prevent the development of an intracranial complication by extension to the cerebellar cavity or because of such an extension. The operation is undertaken only in cases of diffuse suppurative labyrinthitis, since these are the only ones which produce these serious complications. Since the diagnosis of a diffuse suppurative from a serous labyrinthitis cannot always be made, we restrict the labyrinth operation first to those cases in which careful functional tests disclose a complete suppression of function, not alone of hearing but of the semicircular canals in the affected ear. Of these cases only those are selected for a labyrinth operation in which clinical symptoms exist, requiring either a simple or a radical mastoid operation, or where, in the absence of such indications, symptoms of an intracranial complication from an extension of the labyrinth infection have already begun to appear. The operation on the labyrinth is always preceded by a radical mastoid. The effort is then made to secure adequate drainage from the labyrinth by chiselling away the promontory, beginning at the lower margin of the oval window. A second opening into the vestibule is then undertaken from behind the facial ridge. The horizontal canal is opened where this structure lies exposed in the bottom of the antrum. The canal is then followed forward until the vestibule is freely open from this side. This much can be readily carried out by anyone sufficiently familiar with the anatomy of the temporal bone to warrant his undertaking a radical mastoid operation. It is possible also to accomplish a more complete exenteration of the labyrinth, and this is the operation of choice, especially where symptoms of an intracranial complication already exist.

Sinus Thrombosis.—The most common of the more serious complications of suppurative otitis media is thrombosis of the lateral sinus. This venous channel courses along the inner aspect of the mastoid process and is therefore exposed to extension of disease from the mastoid in both the acute and chronic otitis media. There are a few clinical facts to be kept in mind in diagnosing the presence of a thrombosed sinus and in determining the proper course of treatment for this condition.

Symptoms.—The symptoms of sinus thrombosis are, as a rule, so characteristic that one experiences little difficulty in making a diagnosis. The symptoms are those of thrombosis of any large vein. There is a sudden rise of temperature to 104° or even 106° F., preceded, as a rule, by a more or less severe chill, and followed in a few hours by a sudden drop to normal or lower, associated with a profuse perspiration. This phenomenon may repeat itself as often as once each day or the attacks may be separated by intervals of several days. In the interval between the attacks the temperature may remain normal and the patient feels quite well. An examination of the blood will disclose a marked leukocytosis and blood cultures will disclose a bacteremia. The clinical symptoms are not unlike those produced by malaria, from which the disagnosis may be made by an examination of the blood for the plasmodium. On the other hand it is not so uncommon when operating on a case where these symptoms have begun, to discover no tangible evidence of sinus thrombosis. The explanation here may be that the symptoms have been caused by the escape of minute emboli into the blood stream from thrombosed veins in the mastoid process. In such cases the symptoms disappear promptly after the infection has been eradicated from the mastoid.

It is not such an uncommon experience to discover in the course of a mastoid operation a solidly thrombosed sinus in a case where there has been no symptom suggesting such a complication. The explanation here seems to be that as the infection from the mastoid begins to invade the sinus wall the sinus becomes occluded by a protective thrombus, and where the process of repair is active enough the bacterial invasion of the thrombosed sinus is, for the time at least, inhibited. In such cases there is evidently nothing to be gained by a removal of this protective thrombus. The important thing is to eradicate the focus of infection in the mastoid process. Unnecessary manipulations in removing the thrombus may even be harmful by increasing the danger of systemic infection. How far this conservative policy may be followed to advantage in other cases of thrombosis where the characteristic symptoms have appeared is a question about which there is still a difference of opinion. In cases in which the breaking down of the thrombus has taken place and the sinus is found filled with pus the ligation of the jugular in the neck followed by as thorough a removal of the infected thrombus as is possible seems justified. But where the thrombus has not disintegrated and no palpable evidence of softening can be detected it may often be to the best interests of the case not to do more than a thorough exenteration of the diseased mastoid and a slitting open of the sinus to provide adequate drainage, allowing the protective clots to remain rather than to remove them only to have them replaced by a fresh thrombus.

Treatment.—An operative exposure of the lateral sinus is always preceded by a simple mastoid exenteration in acute otitis media, and the radical operation in cases where the trouble has developed as a complication of chronic suppurative otitis media. The bony wall of the sinus is removed by first making an opening with a gouge held quite flat, so as not to enter the sinus. As large an exposure as desired is then readily made with suitable rongeur forceps. The color and normal luster of the sinus is usually altered when the vessel is thrombosed. When a solid thrombus exists this can be detected by pressure over the sinus with the finger. When one is in doubt an aspirating needle may be introduced, the needle being held as flat as possible, so as to make a slanting puncture through the sinus wall. The presence of a parietal thrombus, one only partially occluding the sinus, may not be detected by this method. When the thrombus is found broken down the wall of the sinus should be freely slit and with a dull curette only the softened part of the thrombus removed, care being taken not to disturb the solid thrombus at either end. In some cases in which the symptoms of sepsis have been well established and the sinus is found filled with pus the more radical procedure of ligation or removal of the jugular followed by as thorough removal as possible of the infected thrombus may be resorted to. When the symptoms clearly point to thrombosis and no thrombus is discovered in the sinus it is probable that the bulb of the jugular is thrombosed. If after pressing the blood out of the sinus and tamponing the upper end by placing a gauze compress between the sinus and the bony wall it is seen that the sinus remains collapsed one can feel quite sure that the bulb is thrombosed. The ligation of the jugular in the neck with its partial or complete excision should precede an effort to dislodge the clot in the bulb.

Otitic Meningitis.—Meningeal involvement in suppurative otitis media is not an uncommon complication in both the acute and chronic forms of middle-ear disease. By far the most frequent type is a circumscribed involvement of the dura—a pachymeningitis. This is found in the middle brain fossa where the dura comes in contact with the roof of the middle-ear chambers. But more frequently is the posterior fossa involved in the form of a perisinus infection. When the outer surface of the dura is involved we speak of an extradural meningitis, and when the drainage is interfered with this condition is always associated with an extradural abscess. Less frequently the inner aspect of the dura is the seat of inflammation, forming the so-called subdural abscess.

An external pachymeningitis without the formation of an extradural abscess runs its course without symptoms, and even when an extradural abscess exists the only symptom may be a more or less persistent headache unless the abscess is of unusual size, when it may produce pressure symptoms not unlike those of a brain abscess. The subdural abscess sooner or later gives rise to symptoms characteristic of a true brain abscess. The diagnosis of a pachymeningitis can sometimes be surmised from the continued severe headache in the absence of other symptoms of intracranial disease. This condition is, however, often uncovered unexpectedly in the course of an operation on the mastoid. When there is a persistent headache and a purulent discharge from the unhealed mastoid wound after a mastoid exenteration in acute otitis media an extradural abscess above the roof of the middle-ear chambers, and especially at the extreme outer upper angle of the mastoid, is frequently found.

An inflammation of the subarachnoid space between the arachnoid and the pia produces the so-called leptomeningitis. This may result from direct contact with an inflamed dura, but it also develops from lymph or bloodvessel communications with the middle ear as well as by extension from infection in the labyrinth. This form of meningitis may be circumscribed or diffuse, and either form may be serous or purulent in character. There is no fundamental difference between the serous and purulent forms of meningitis. Both are infectious in origin. The transition is a gradual one, the difference being due principally to the varying virulence of the infectious agent. Both forms may have a fatal termination, and even the diffuse purulent meningitis occasionally recovers.

The course of meningitis varies widely. In a few fulminating cases the disease ends fatally within one or two days. The purulent form usually terminates fatally in the course of the first week, but may last for three or four weeks. There is an intermittent form of meningitis which is sometimes secondary to labyrinth suppuration, where the attacks with the characteristic symptoms of meningitis may be separated by intervals of months or even years, until the patient finally succumbs to a diffuse purulent meningitis. The autopsy in such cases discloses the evidences of preceding inflammation. That patients recover from meningitis of otitic origin is well known. Formerly it was supposed that only the serous cases could recover. It is now proved beyond a doubt by evidence of pus found on incising the dura that cases of purulent diffuse meningitis do occasionally make a recovery.

Symptoms.—The symptoms are so characteristic that little difficulty is experienced in recognizing the existence of meningitis. Severe headache, elevation of temperature and dulling of the sensibilities, gradually terminating in coma, are always present. Rigidity of the neck is usually conspicuous and vomiting irrespective of taking food is very frequent. A positive Kernig is perhaps the most characteristic symptom, especially as it indicates an extension to the spinal canal and is not found in other intracranial complications. A number of associated symptoms sooner or later appear, such as optic neuritis, paralysis of the abducens, as well as of other cranial nerves and finally of the extremities. The pulse in the beginning may be retarded, but toward the end is rapid and irregular.

Diagnosis.—It is only in the beginning that one may experience any difficulty in making a diagnosis from the clinical symptoms. In doubtful cases the lumbar puncture is of great assistance. When the spinal fluid is cloudy and contains a large number of leukocytes, or when it is clear but under considerable pressure, the diagnosis of meningitis is positive. Further than this one is not justified in going. The withdrawal of a more or less purulent spinal fluid does not prove that the fluid in the cranial cavity is also purulent, since the increased leukocytes in the spinal fluid may be in the nature of a sediment from a diffuse serous meningitis, and *vice versa,* the withdrawal of a relatively clear fluid does not exclude the possibility of purulent meningitis existing in the cranium. Even when the spinal fluid is found to be normal one cannot be certain that the spinal sac may not be shut off from the cranial cavity by a fibrin plug. On the whole, however, a distinctly purulent fluid withdrawn by the spinal puncture means a purulent condition of the meninges within the cranium.

Treatment.—In view of the facts which we now possess regarding the course of otitic meningitis the treatment for these cases is quite clear. As early as possible the focus of infection in the mastoid should be eradicated, the dura split and free drainage established. Repeated spinal puncture to relieve the ever-recurring increased pressure is to be employed. With this treatment many of the cases of serous meningitis will get well, and occasionally even a case of unquestionable diffuse purulent type may recover.

Brain Abscess of Otitic Origin.—Abscess of the brain is a much more frequent complication of chronic suppurative otitis media than of the acute disease. It develops either through direct extension by contact with a perforating disease of the mastoid or through extension of infection by way of lymphatics and bloodvessel connections with disease in the middle-ear chambers or in the labyrinth. The location of such abscesses is, therefore, as a rule, more or less definitely determined. For the most part they lie in the middle brain fossa just over the middle-ear chambers, or less frequently in the posterior fossa in contact with the posterior aspect of the temporal bone. When the infection extends through the roof of the tympanum or mastoid a temporosphenoidal abscess develops. When it enters the posterior fossa a cerebellar abscess forms, the location of which may be either anterior, that is, in close relation to the lateral sinus, which is more frequent, or it may develop deep in the cerebellum where this structure comes in contact with the posterior aspect of the petrous bone near the opening of the internal meatus or the aqueductus vestibuli. The majority of brain abscesses are surrounded by a distinct capsule and are filled with a thick, more or less odorless pus. A smaller percentage lacks the capsule, the surrounding brain substance being more or less extensively involved. The pus in these cases is usually most offensive.

Symptoms.—In order to keep in mind the multiform symptoms which accompany brain abscess, it is convenient to consider these symptoms as they occur during the several stages in the course of the abscess.

(1) Is the "initial stage." Here the characteristic symptoms are those of meningeal irritation where fever, headache and vomiting point clearly to a circumscribed infection of the meninges. (2) Is the "latent stage." Here the complaint is from headache and a sense of pressure in the head. The pain is restricted usually to the same side, but not necessarily located over the seat of the abscess. Not infrequently there is sensitiveness to percussion over a temporosphenoidal abscess. The patient appears ill, has no appetite, loses weight, is mentally depressed or may experience exhiliration. His face takes on a grayish color. There may be attacks of vertigo and vomiting. Seldom is there any elevation of temperature. (3) Is the "manifest stage," when symptoms of intracranial pressure and focal symptoms appear. Common to both forms of brain abscess is the slowing of the pulse, and optic neuritis. These are, on the whole, more often seen in cerebellar abscess. The focal symptoms depend on the location of the abscess. A peculiar form of sensory aphasia, "word blindness," where the patient recognizes an object but cannot recall the name, is often a symptom of temporosphenoidal abscess of the left side in right-handed individuals. Nerve deafness on the side opposite the lesion is also observed in cases of cerebral abscess as well as crossed hemiparesis.

Cerebellar abscess often gives rise to distinct ataxic symptoms, with vertigo and nystagmus, which resemble those of labyrinth involvement. These two conditions may be confused, especially because a suppurative labyrinthitis often precedes the development of a cerebellar abscess. The differential diagnosis may be baffling unless one is an aurist experienced in diagnosing labyrinth disease. The following points may be of assistance in cases in which a suppuration of the labyrinth precedes the development of symptoms suggesting cerebellar abscess. The infection of the labyrinth from which a cerebellar abscess develops is always a diffuse labyrinthitis, which always produces a total destruction of the hearing as well as the function of the semicircular canals. The vertigo and nystagmus which occur as the result of the sudden destruction of the labyrinth is always greatest at the onset of the disease and diminishes gradually, disappearing entirely in the course of a few weeks. The quick movement of the eyes in the resulting nystagmus is toward the opposite side. When an intracranial extension supervenes as the result of an extension of the labyrinthitis an ever-increasing vertigo and nystagmus gradually develops. The quick component of the nystagmus is now usually directed toward the affected side.

During the "manifest stage" of brain abscess, symptoms of pressure causing paralysis of various cranial nerves develop. The fourth or "terminal stage" is marked by collapse, as the result of a rapidly spreading meningitis or of the rupture of the abscess into the ventricle. As a matter of fact, both the first and fourth stages are quite transitory, whereas the latent stage may last for months or even years until a sudden unexpected fatal termination supervenes.

Treatment.—An operation for the location and relief of a probable brain abscess, just as the operation for any of the intracranial complications of suppurative otitis media, is always preceded by the simple mastoid exenteration in the acute cases, and the radical operation in the chronic cases. The object is first of all to eradicate the source of the infection in the middle ear. Another reason for this course is that the location of the abscess is most readily made by tracing the course of the infection from the middle ear. When one finds no pathway leading toward the brain abscess one proceeds cautiously to make a search either in the middle-brain fossa or in the posterior, depending upon whether the symptoms point more toward a temporosphenoidal or cerebellar involvement. When one suspects an abscess in the middle fossa the whole roof of the middle-ear chambers is removed with bone forceps from the tympanic orifice of the Eustachian tube well back toward the outer angle of the pyramid. The simple mastoid should be made into the radical in such cases. Should a careful examination of the exposed dura disclose no alterations pointing to the course of the infection the next step is to puncture the dura with a suitably large aspirating needle, penetrating the brain substance upward and backward, not over four centimeters. In case an abscess is located by this means the bone is freely removed over the abscess by means of bone forceps. The dura is freely incised and a suitable drain is then introduced, either in the form of a cigarette drain or a strip of gauze. The failure to draw pus into the needle does not exclude the possibility of an abscess. When the symptoms are pressing enough the exploration may now be carried farther by making an incision in the dura, to be followed by three or four punctures with a knife.

When one suspects a cerebellar abscess it is important to remember that those abscesses which follow an infection of the labyrinth are deeply located along the posterior aspect of the temporal bone, near the orifice of the internal auditory meatus. The abscess in such cases is reached most readily by chiselling away the posterior angle of the petrous bone just in front of the lateral sinus. Injury to the labyrinth is of no consequence, since the function of this organ has already been destroyed in the course of the labyrinthitis. Aside from these cases of labyrinth origin all other cerebellar abscesses are located anteriorly, that is, in more or less close proximity to the lateral sinus, even in those cases in which the sinus itself has not been infected. These abscesses are reached more readily by making an opening just posterior to the knee of the sinus. In either case the sinus itself should be freely exposed.

The after-treatment of brain abscess requires frequent changing of the dressings in order to facilitate adequate drainage for the profuse discharge. It is especially important not to leave out the drain too early.

SURGERY OF THE NOSE AND THROAT.

By JOSEPH C. BECK, M.D.

THE NOSE.

In discussing the surgical management of the nose, we will consider the subject under two separate heads, namely:

A. The exterior of the nose.

B. The interior of the nose.

The exterior component is made up of a bony and cartilaginous framework and covered with skin. The bones are: the nasal spine of the frontal bone, the two nasal bones, the two nasal processes of the superior maxilla, and the rostrum of the same bone. The cartilages are the lateral masses joining the cartilaginous portion of the septum which forms the tip of the nose, as well as the nostrils (Fig. 188).

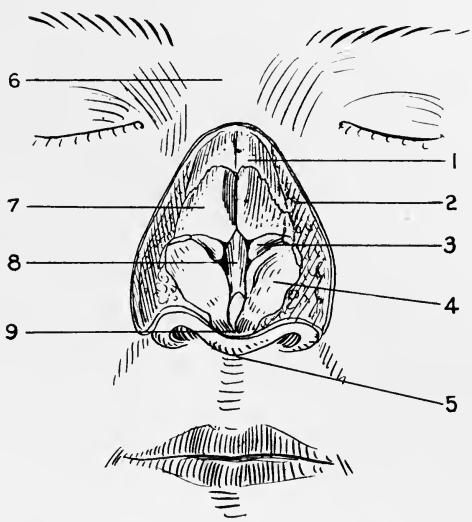


Fig. 188.—1, os nasale; 2, processus nasi max. sup.; 3, cartilago sesamoidea; 4, cartilago alaris major; 5, max. sup.; 6, spina os frontali; 7, cartilago nasi lat.; 8, cartilago septi nasi; 9, rostrum os.

The interior component of the nose is also made up of bony and cartilaginous structures, but these are covered by mucous membrane. The bones entering into the formation of the interior component are: the ethmoid with its superior and middle turbinated bodies (Fig. 189); ethmoid labyrinth, known as anterior and posterior ethmoid cells

(Fig. 190); the cribriform plate and the perpendicular plate (septum) (Fig. 191); the superior maxilla with its antrum cavity (Fig. 192);

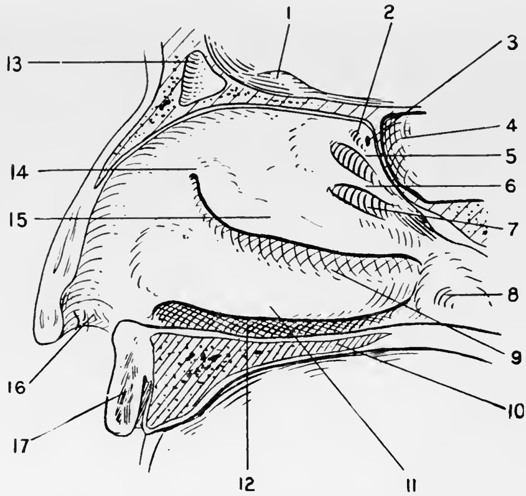


Fig. 189.—1, crista galli; 2, recessus sphenoethmoidale; 3, aperture sinus sphenoidales; 4, sphenoid sinus; 5, concha nasalis suprema; 6, concha nasalis suprema; 7, meatus nasi sup.; 8, ostium pharyngeum tubæ; 9, meatus nasi med.; 10, os palatina; 11, concha nasalis inf.; 12, meatus nasalis inf.; 13, frontal sinus; 14, agger nasi; 15, concha nasalis med.; 16, vestibulum; 17, labium sup.

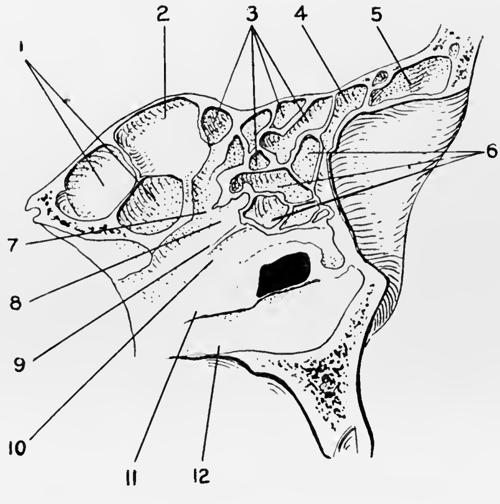


Fig. 190.—1, Left sphenoid; 2, right sphenoid; 3, post ethmoid; 4, infundib.; 5, sinus frontalis; 6, anterior ethmoid; 7, sup. turbinated; 8, sup. meatus; 9, mid. turbinated; 10, mid. meatus; 11, inf. turbinated; 12, inf. meatus.

the inferior turbinated body (Fig. 189); the vomer (Fig. 191) and the palate bone (Fig. 189). Since the surgical diseases of the exterior component, such as fractures, abscesses, tumors, deformities and malformations, will be taken up in other chapters, the diseases of the

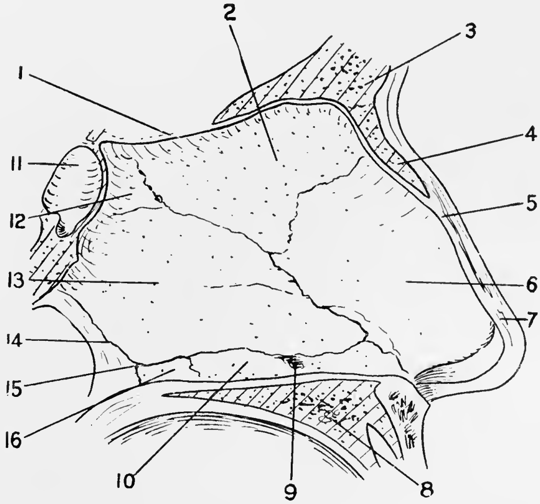


Fig. 191.—1, lamina cribrosa; 2, lamina perpendicularis; 3, os frontale; 4, os nasale; 5, cartilago nasi lat.; 6, cartilago septi nasi; 7, cartilago alaris major; 8, processus palatinus; 9, canalis incisivus; 10, crista nasalis maxillæ; 11, sinus sphenoidalis; 12, crista sphenoidalis; 13, vomer; 14, choana; 15, spina nasalis post.; 16, crista nasalis ossis palatini.

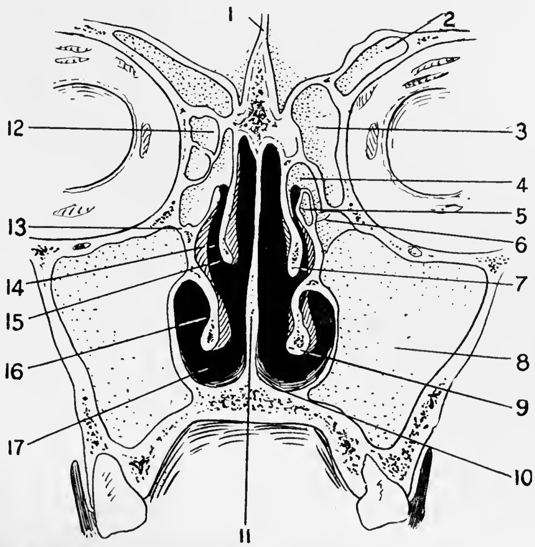


Fig. 192.—1, crista galli; 2, sinus frontalis; 3, cellula ethmoidalis ant.; 4, bulla ethmoidalis; 5, processus uncinatus; 6, ostium sinus max.; 7, concha nasalis med.; 8, sinus max.; 9, concha nasalis inf.; 10, processus palatini; 11, septum nasi; 12, bulla ethmoidalis; 13, ostium sinus max.; 14, meatus nasi. med.; 15, concha nasalis med.; 16, concha nasalis inf.; 17, meatus nasi inf.

internal component, namely, only that which is lined with mucous membrane will be considered here.

In order to be able to make a correct diagnosis, and to administer proper treatment, it is essential for the surgeon to see clearly within this dark area (the nasal cavity). This is only possible by a thorough training with the use of the reflected light. Practically no operative procedure can be performed without the use of good illumination.

The principal pathologic conditions met with in the interior component of the nose are:

1. Obstructions.
2. Infections.

I. **Septum.**—Obstruction is most frequently caused by a deflection of the septum, however there is usually some concomitant hypertrophy of the middle and inferior turbinated bodies. The deviation of the septum is usually in the anterior or cartilaginous portion, but the bony portion has some deflections with excrescences called ridges and spurs. These are formed along the junction of the bony and cartilaginous portion of the septum, as well as the union between the vomer, perpendicular ethmoid and superior maxilla (floor of the nose, known as maxillary ridge). A very important anatomical and surgical point is the periosteum and perichondrium which traverses the septum anteriorly as it comes over from the floor of the nose. There are at times septa deflections that protrude from one side or the other of the nose, carrying with it the tip and giving the nose a crooked appearance. Aside from causing obstruction to breathing the deflections give rise to difficulty in ventilating the nasal accessory sinuses and middle ear, predisposing to infection and deafness. Another complaint often expressed is pain due to the pressure of the septum laterally against the sensitive structures. These pains may be referred and neuralgic in character as is a toothache.

Treatment.—Aside from temporary relief by shrinking with adrenalin and other astringents, there is but one rational thing to do and that is to operate. Before the classical submucous resection of the nasal septum was devised about fifteen years ago, there was a great multiplicity of operative procedures from a resection of a ridge or spur, to an Ash operation; but today only the submucous resection is acceptable.

Technic.—Patient is placed in a semi-recumbent position, a cotton applicator is soaked in adrenalin solution one to one thousand, and this is subsequently dipped into the flaked cocaine (commercial product). By means of this mixture both sides of the septum are gently swabbed. About 10 grains of the flakes of cocaine is consumed in the average case, and it requires about fifteen minutes before the patient is ready for operation.

Steps of Operation.—1. Introduction of the Heffernan self-retaining nasal speculum (Fig. 193) on the convex side of the deflection.

2. Incision anterior to the greatest prominence of the deflection, down to the cartilage. This incision should be carried well down to the floor of the nose (Fig. 194).

3. By means of the same knife (Fig. 195) the mucoperichondrium

is elevated for a slight distance with the greatest care, in order not to shred it, until one reaches the much looser attachment further back.

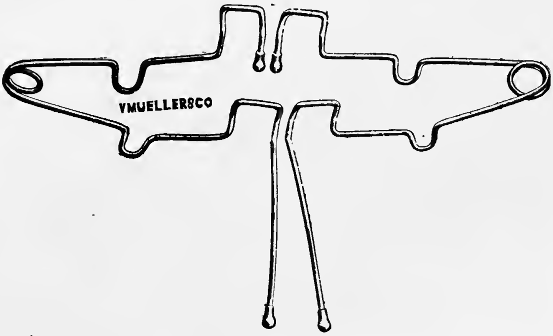


FIG. 193.—Heffernan nasal speculum.

4. By means of a semi-blunt elevator (Fig. 196) the entire cartilage as well as the bone, is separated from the mucoperiosteum and perichondrium (Fig. 197).

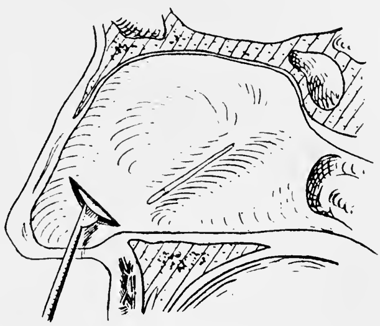


FIG. 194.

5. At the anterior portion of the septum, near the floor of the nose, where, as mentioned before, the perichondrium passes through the cartilage, it is necessary to employ the knife to free this attachment before one can dissect the mucoperichondrium down to the floor.

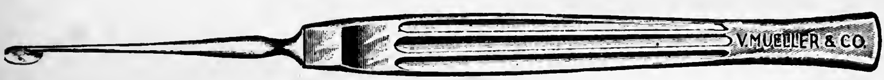


FIG. 195.—Freer's septum knife.

This portion of the technic is very difficult and may result in a tear especially when there previously existed an ulceration at that point (Fig. 198).

6. By means of the knife the cartilage is cut obliquely at the same point, as the original incision of the mucoperichondrium. Great care

must be exercised not to cut through the mucoperichondrium on the opposite side.

FIG. 196.—Hajek-Ballinger elevator.

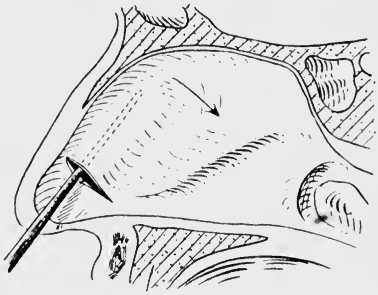


FIG. 197.

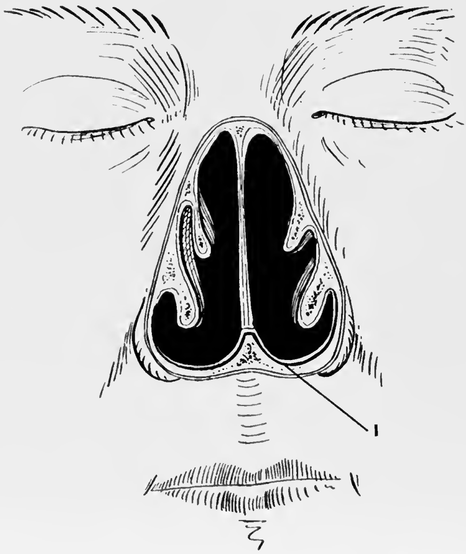


FIG. 198.—1, perichondrium passing through septum.

FIG. 199.—Freer's elevator.

7. Insertion of the second Heffernan speculum into the opposite nostril.

8. By means of the fine blunt dissector (Fig. 199) the opposite mucoperichondrium is separated from the cartilage and bone, the same as on the convex side.

9. The same procedure of severing the perichondrium as it passes through the anterior portion of the septum, is employed, thus having freed both sides of the septum through a single incision.

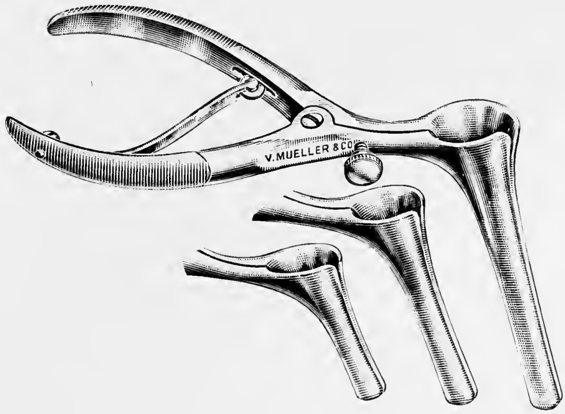


Fig. 200.—Killian's nasal speculum.

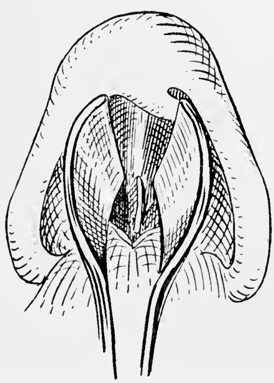


Fig. 201.

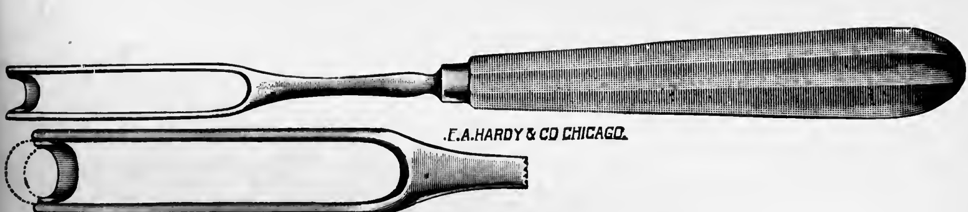


Fig. 202.—Ballenger's swivel knife.

10. Insertion of a thin-bladed bivalve speculum (Fig. 200) into the incision, each blade on either side of the cartilage (Fig. 201).

11. Slight opening of this speculum exposes the cut surface of the septum. By means of the Ballenger swivel knife (Fig. 202) the blade of which straddles the cartilage at the upper section, remove a section of the cartilage (Fig. 203). The first sweep of the knife is made up and backward by a pushing motion until the bone is encountered. Care must be exercised not to pass the swivel knife too close to the bridge of the nose, thus weakening the support which may result in a saddle nose, especially in case of infection or trauma.

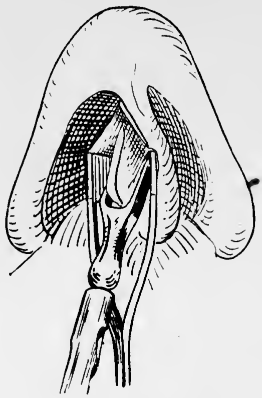


Fig. 203.

The next sweep of the knife is downward, and continuing forward, when the section of the cartilage will have been completed.

12. By means of a good grasping forceps (Fingers, Fig. 220) the edge of the cut cartilage is grasped and withdrawn even though it may be much larger than the incision in the mucoperichondrium.

13. The removal of the ridge which is very frequently present near the floor of the nose is best accomplished by a gouge (right and left, Fig. 204) which is guarded against the possible tearing of the mucoperichondrium flap (Fig. 205).

Fig. 204.—Black's chisel.

14. Bony deflections are best removed by means of a forceps (Fig. 206, Luc-Brünning) which grasps the septum on either side (Fig. 207) and by a slow twisting motion is broken. This forceps removes only the bone within the grasp of its blades and therefore is a safeguard against possible linear fractures beyond the point intended.

15. After bringing the flaps in apposition, both sides of the nose are to be packed. In case of the incision having been made in the mucocutaneous junction, it is best to unite it by a single stitch (Fig. 208), thus aiding in more rapid healing, with less crust formation.

16. Packing of the nose may be done by splints made of compressed cotton, originally used by Bernay. These splints are of different lengths (Figs. 209 and 210). While introducing the splint or packing,

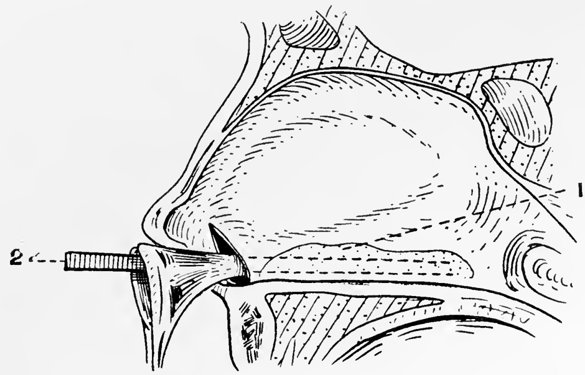


Fig. 205.—1, ridge; 2, chisel.

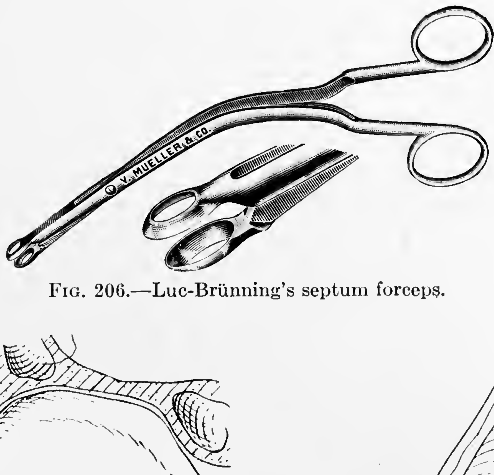


Fig. 206.—Luc-Brünning's septum forceps.

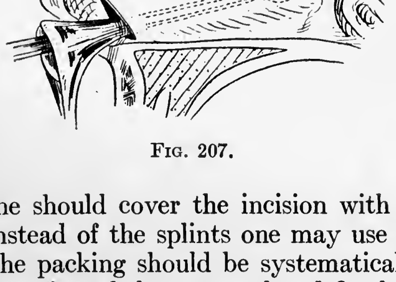


Fig. 207.

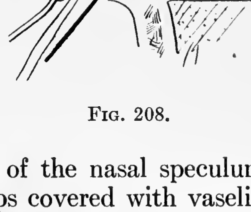


Fig. 208.

one should cover the incision with the blade of the nasal speculum. Instead of the splints one may use gauze strips covered with vaselin. The packing should be systematically placed into the nose, layer for layer from below upward and firmly pack both sides, thus preventing the possibility of a hematoma. A small strip of adhesive plaster is passed across the nostrils preventing the expulsion of the packing in case of sneezing (Fig. 211).

After-treatment.—Remove packing next day.

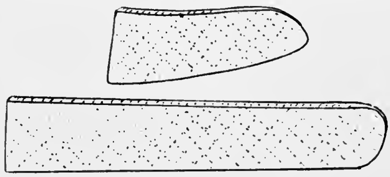


Fig. 209.—Bernay's splint.

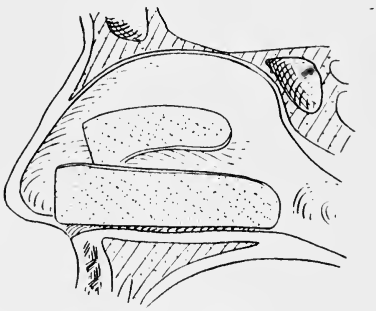


Fig. 210.

Fig. 211.

Complications.—These occur very seldom. One of the most common complications is a "hematoma" between the mucoperichondrium and periosteal flaps. This always causes an obstruction to breathing. The cause is that the packing in the nose was too loose, or that it was removed too soon. At times this hematoma becomes infected, adding pain and temperature to the symptoms. In such cases it is best to open the original incision, remove infected blood clot, mop out with iodin and pack gauze between the mucoperichondrial flaps for twenty-four hours. After removing the gauze, the flaps are again approximated and the nose is packed as after operation for twenty-four to forty-eight hours.

Occasionally in spite of proper packing a continuous "oozing" or even hemorrhage may take place. This is either due to a blood dyscrasia or there may have been an injury to the anterior palatine artery, while removing the ridge at the floor and not packed sufficiently tight at that point.

Secondary infection of the nasal accessory sinuses, middle ear and tonsillitis also occur, especially if the packing is allowed to remain longer than twenty-four hours or if possibly, the septum operation was performed while there was an acute inflammation about the nasal or pharyngeal cavities. The management of these complications is referred to elsewhere.

Local and general sepsis in the form of a meningitis, septic sinus thrombosis (great longitudinal) has been reported following septum resections.

Flapping of the resected septum due to excessive removal, especially of the bony portion, is at times met with. It is very annoying especially when the patient attempts to expire the air forcibly through the nose, which causes an obstruction. To remedy this difficulty is either to reopen the mucoperichondrial and periosteal flaps and insert a piece of cartilage of a resected septum of another patient, or make a linear perforation through the septum near the floor of the nose somewhat back. This is best done by an electric cautery and subsequently kept open, by inserting a probe through the incision daily for about one week.

II. **Inferior Turbinated Body.**—Obstructions to breathing, ventilation and drainage of the nasal accessory sinuses and ears, are the most frequent difficulties encountered, when this structure is pathologically changed. The various pathological changes that the writer has investigated, especially by histological examination are: Turgescence (Fig. 212), papillary hypertrophy ((Fig. 213), epithelial hypertrophy (Fig. 213), atrophy (Fig. 214).

There are other pathologic changes both acute and chronic which, however, seldom if ever call for surgical intervention. These are the acute inflammations, the chronic engorgement associated with renal and cardiac diseases, the ischemic or boggy type usually present in the hyperesthetic form of rhinitis and the rapid alternating dilatation and contraction as found in certain vasomotor conditions. Excluding these later forms and the atrophic inferior turbinate, the operative interference does not differ much in the first three forms mentioned. One of the principle facts in reference to the inferior turbinate bodies which is to be remembered, is to be extremely, let me repeat it, extremely conservative in the removal or destruction of any part of them. Perhaps no other structure within the nose has been more abused by the general surgeon and specialists, than the inferior turbinate, with very annoying and lasting after-effects of dryness both of the nose as well as of the throat.

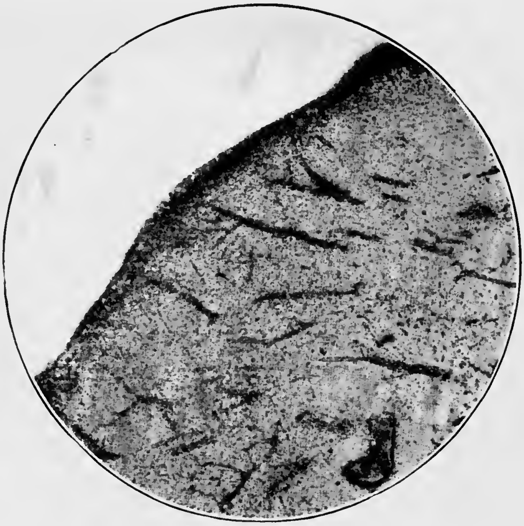


Fig. 212.—Chronic intumescence of the inferior turbinate body. Marked inflammation of the surface epithelium. New bloodvessels. Almost complete atrophy of all the glands.

Fig. 213.—Very marked thickening of the epithelium of the papilla.

Treatment.—Three principal methods are employed usually in the order mentioned:

1. Actual galvanic cautery.

2. Crushing.
3. Limited removal.

Actual Cautery.—A good transformer, cords, handle and points are required to do good work (Fig. 215).

Fig. 214.—Inferior turbinate in atrophic rhinitis (chip removed experimentally). Showing metaplasia of epithelium of the median side and thickening of the antral side. Mucous glands are still present, although distended.

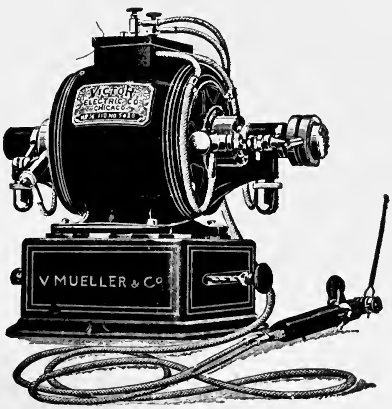


Fig. 215.—Galvanocautery.

Local anesthetic, flaked cocaine limited to the surface of inferior turbinate.

Operation.—Heat the cautery point to slightly more than the red heat.

1. Introduce the electrode cold and apply to the most posterior portion of the turbinate and at the junction of the lower one-third

with the upper two-thirds (Fig. 216) and then heat by making contact of trigger of handle.

2. A slow short see-saw movement burrowing the electrode until the bone is felt.

3. Continue the same procedure on a line forward, until the most anterior portion of the turbinate is reached, when the electrode is withdrawn still hot. Care must be taken in withdrawing the heated point, not to touch any part of the vestibule of the nose.

4. Fill the entire nasal cavity with white vaselin from a collapsible tube.

After-treatment.—Have the patient repeat this introduction of vaselin every two or three hours. The nose should be examined for several days after and the turbinated body kept separated from the septum, thus preventing the formation of a synechia.

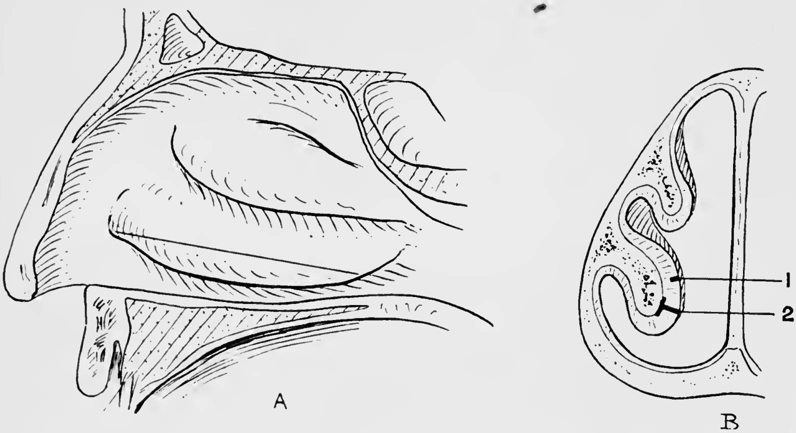


FIG. 216.—1, faulty technic; 2, location of actual cautery line (correct).

CRUSHING.—This procedure is a makeshift between the galvanic cautery and resection.

Technic of Operation.—The writer's instrument (Fig. 217) known as a conchotribe is inserted in such a manner as to cause the blades to encircle the lower or free border of the inferior turbinated body (Fig. 218) closing the blades completely and immediately releasing will result in the proper shrinkage when healing has taken place. This crushing is started anteriorly and continued backward until the entire length of the lower border of the inferior turbinated body has been crushed. When the posterior portion is reached, one will frequently find a much greater hypertrophy which really causes the greater amount of trouble, especially affecting the mouth of the Eustachian tube. In that case, the crushing blades of the conchotribe should be allowed to remain closed for two or three minutes, thus obtaining better and more lasting results.

There is seldom any bleeding following this procedure, but if it occurs then a long Bernay's splint (Fig. 209), placed in the inferior meatus, will control the same. This should be removed the next day and the after-treatment is the same as after the cautery.

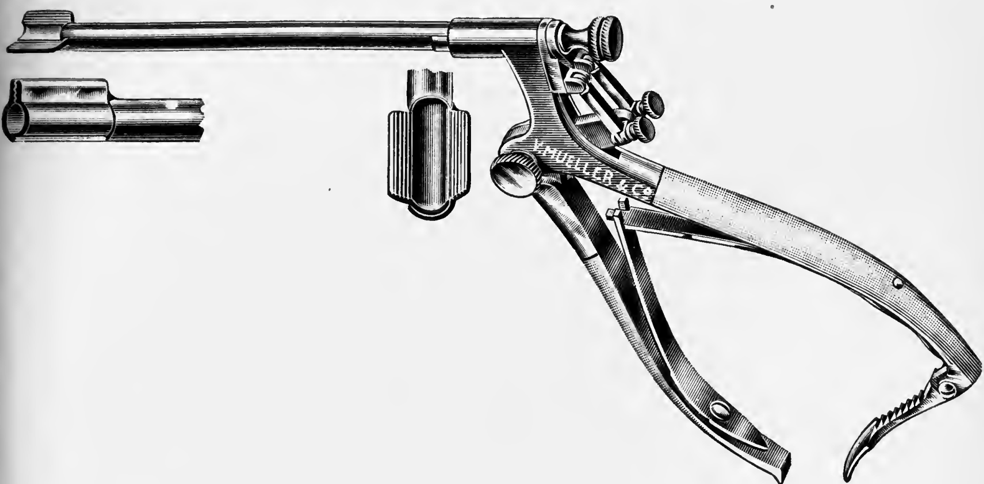


Fig. 217.—Beck's conchotribe.

Resection.—As stated in the beginning only partial resection of the inferior turbinate is permissible in good rhinological surgery and it is confined to the lower or overgrown margins and particularly to its

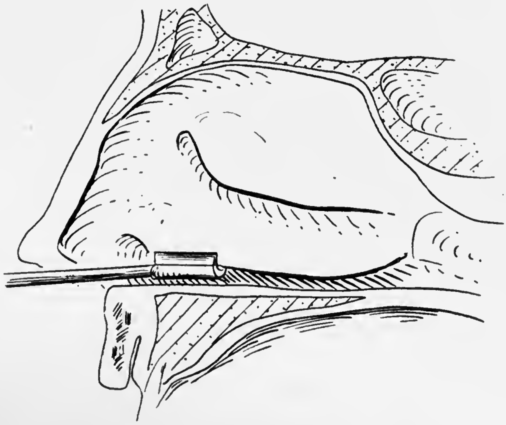


Fig. 218.

posterior portion. This at times takes on the appearance of a tumor with pedicle and after removal or by the aid of a postrhinoscopic mirror will appear studded like a mulberry and therefore carries that name, mulberry hypertrophy.

Technic of Operation.—1. By means of the cutting instrument, author's conchotome, the lower edge, including a thin portion of the bone, is cut from forward back, until the posterior enlargement is reached (Fig. 219).

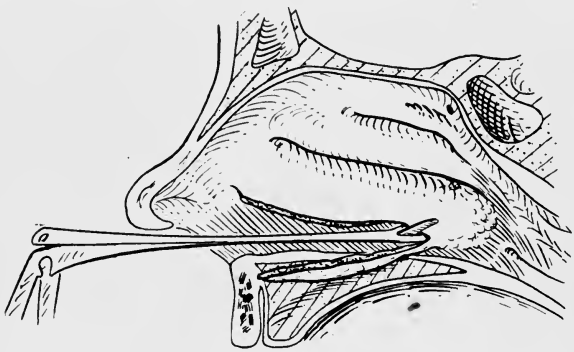


Fig. 219.

2. Grasp this posterior enlargement with a threaded Michel clip. (This is applied by a small alligator forceps, described in the septum operation as Fingers, Fig. 220.)

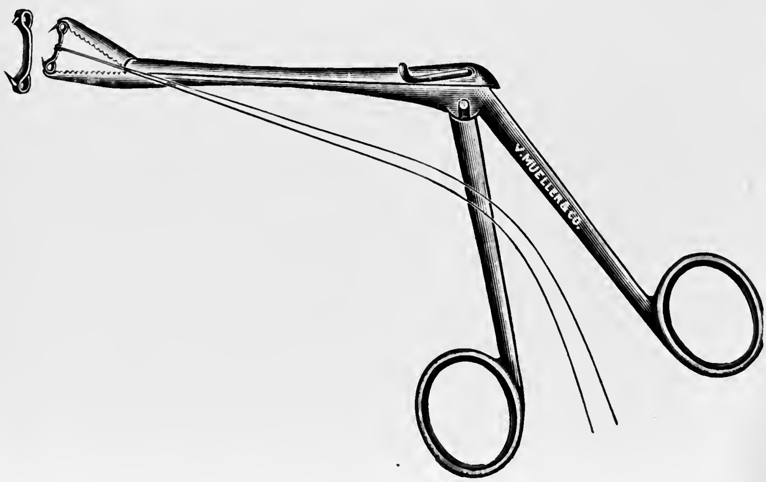


Fig. 220.—Michel clip threaded.

3. Pass a snare about the already resected lower border and the thread of the Michel clip as far back as the posterior end. By slight traction on the above-mentioned thread of the clip (Fig. 221) the posterior end is easily encircled. Drawing the snare wire down will remove the entire resected mass which is withdrawn by the threaded Michel clip.

Bleeding is at times very free, especially from the posterior end, consequently always employ the conchotribe after resection.

4. The conchotribe is applied as was described in the technic of crushing (Fig. 218).

5. A long Bernay's splint is inserted for twelve hours.

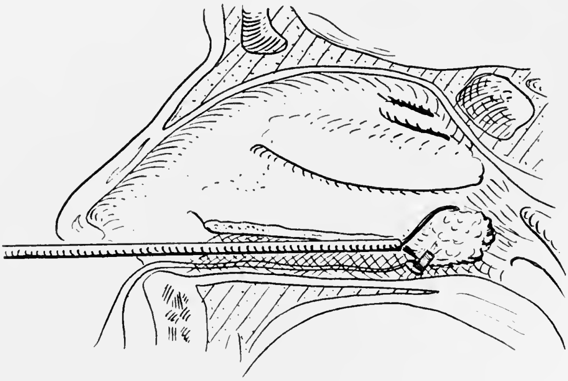


Fig. 221.

Nasal Accessory Sinuses.—In the study of the surgery of these sinuses, it is necessary to consider them both from the intranasal and external routes.

The nasal accessory sinuses are anatomically divided into (*a*) anterior group and (*b*) posterior group.

The anterior group comprises the frontal sinus, anterior ethmoid cells and antrum of Highmore; the posterior group is composed of the posterior ethmoid cells and sphenoid sinus. Surgically, the anterior and posterior ethmoidal cells as well as the sphenoid sinus are attacked intranasally, whereas the frontal sinus and antrum of Highmore may be operated upon intranasally as well as by external methods. The indications for nasal accessory sinus operations are principally to establish ventilation and drainage thus relieving the symptoms of irritation, pain and infection. The presence of pus is one of the cardinal symptoms; however, there are more cases of so-called non-suppurative inflammation of the nasal accessory sinuses calling for operative interference, than those in which pus is demonstrable. These so-called non-suppurative cases are in reality degenerative changes in the bones and mucosa; however, secondary latent infection and retention, especially in the ethmoid labyrinth is acknowledged. Since the advent of the belief of chronic focal infection, these sinuses have assumed greater importance as the seat of the trouble and the drainage and ventilation of the same have given some striking results. The close anatomical relation between the vital structures, as the brain and eyes, is an additional reason for recognizing pathological processes of the nasal accessory sinuses. In the study of the pathology of the various types of nasal accessory sinus disease, the writer has demonstrated, especially histologically, the following types of changes which can in the majority of instances be verified by a good stereoroentgenogram:

1. Chronic suppurative inflammation of the mucosa.
2. Involvement of the bone such as osteitis and necrosis with granulation.
3. Acute inflammatory changes engrafted upon chronic osteitis, necrosis and granulations.
4. Non-suppurative changes as myxomatous degeneration of mucosa.
5. Myxomatous changes of the mucous membrane with the formation of true polypi.
6. Myxomatous changes of the mucous membrane with osseous rarefaction.
7. Marked atrophic changes of mucosa with increase of connective tissue, probably many are luetic; in these, there are evidences of bony rarefaction and necrosis.
8. Neoplasms other than mucous membrane polypi.

In the diagnoses of sinus disease probably no finding is as valuable, as stated before, as the roentgenographic, especially if a stereoscopic picture is made. It is very important to determine the clinical diagnosis from inspection of the nose, the history, etc., in order to interpret properly the picture, in the writer's opinion based upon considerable experience. Only the clinician should interpret the roentgenogram and use it for diagnostic purposes. It stands to reason that if he has been properly trained in this work he is in a better position to do this than the ordinary roentgenologist. It is quite difficult to obtain satisfactory roentgenograms of the sinuses of a uniform technic, owing to the lack of information on the part of the average roentgenologist. They make good chest, abdominal, kidney and bone pictures, but when it comes to the sinuses and mastoids or any other part of the skull, they are far less competent. The symptom of localized pain must not be looked for too closely, because an affection of the sphenoid may cause the pain to be referred to the frontal or vertex region, or an antrum of Highmore affection may cause a frontal or temporosphenoidal pain. Tenderness on light percussion or pressure over the forehead, across the nose and inner surface of orbit and over the anterior surface of the superior maxilla, will suggest the possibility of a frontal, ethmoidal and antral inflammation, although this symptom refers particularly to acute cases or acute exacerbation of chronic diseases.

The periodicity of the pain and headache usually in the early hours of the day, is of considerable value, especially in more acute cases. Symptoms referable to the eyes, especially loss of vision, congestion of the conjunctivæ, disturbance of balance of the extrinsic muscles with small errors of refraction not well corrected by lenses, are some of the very common findings of sinus disease. Nasal obstruction is very commonly complained of, especially when the middle turbinated body is much degenerated or inflamed and especially when there are polypi present. Whenever these are present it means sinus disease, usually ethmoidal and only when these cells are thoroughly removed, can one hope to eradicate these growths and even then recurrences are not at all uncommon.

The constant presence of pus either in the middle or superior meatus is almost certain to indicate sinus disease.

Dizziness is a very common symptom and especially elicited on stooping or walking up and down stairs.

In the non-suppurative form more than in the cases where pus is present, will the patients complain of loss of the sense of smell, or an abnormal sense of smell, owing to the affection of the olfactory nerves.

Very frequently, in the non-suppurative form there is irritation of the sensory nerves, causing a great deal of sneezing, followed by marked discharges of a watery secretion.

Secondary involvements either by direct continuity of structures or by nervous reflexes implicate the pharynx, Eustachian tubes and ears, larynx, trachea, bronchi and even the lungs, giving rise to symptoms from these structures. In sphenoidal disease, particularly do we see frequent pharyngo-laryngo-trachitis developing, causing the patient to cough; bronchitis and asthma are well recognized as being associated with nasal accessory sinuse disease especially the non-suppurative type and attention to these will bring about great amelioration of symptoms both in bronchitis and asthma. Of recent years the pediatrician recognizes the condition of sinusitis in children and the causative influence it may have on their so-called colds with bronchitis. Equally good results are obtained in this later condition when these diseased sinuses in children receive proper attention.

Transillumination is of particular value in diseases of the antrum of Highmore, although in some large frontal sinuses in which the anterior wall is anatomically not too thick, it will show a shadow in case of disease.

Examination of teeth, especially by the aid of a roentgenographic film, will aid in establishing a diagnosis of an antrum infection from this source in many instances.

Puncture of the antrum by a trocar needle and washing out, will at times demonstrate pus when no other objective finding is present.[1]

Treatment.—In the suppurative form of sinus disease only can one expect any results from non-surgical treatment, but let it be well borne in mind that chronic sinus disease has, as a rule, so changed the tissues that operative interference is the only measure to relatively cure a patient. I say relatively, because when once a sinus is chronically affected only the most radical procedure can bring about a cure, and that is principally confined to the frontal sinus and antrum of Highmore.

The majority of acute sinus diseases, especially if not engrafted upon previous chronic diseased conditions, will recover through simply assisting drainage and ventilation by topical applications of adrenalin, 1 to 1000, and cocain, 2 per cent., to either side of the middle turbinated body. As soon as the very acute symptoms have subsided, then the use of irrigation under direct inspection by means of

[1] The enumeration of the signs and symptoms above are arranged in their importance and frequency and not systematically as objective or subjective.

Beck's wash bottle apparatus (Fig. 222) is indicated. Normal salt solution is employed in the vicinity of the openings to the sinuses, that is under the middle turbinate anteriorly and between it and the septum further back, will aid in the resolution of the process. The

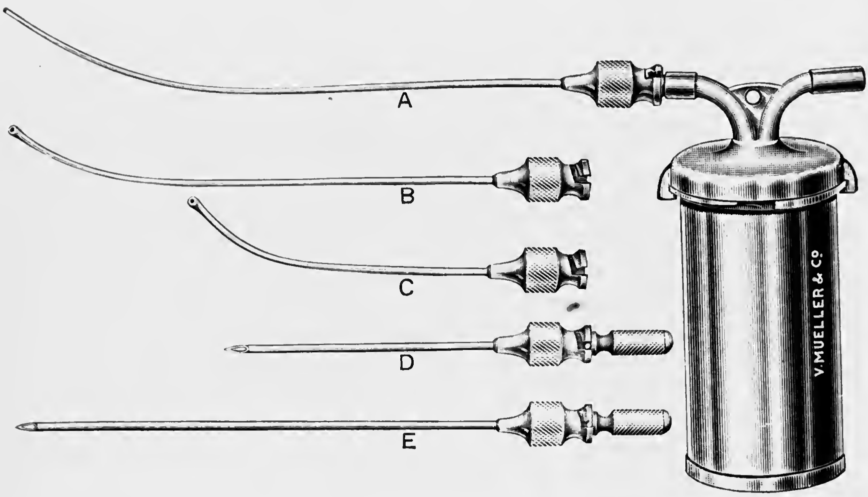


Fig. 222.—Beck's wash-bottle.

use of gentle suction by the aid of Beck's suction apparatus (Fig. 223), following the instillation of adrenalin solution, 1 to 5000, by the writer's method will give further relief. This line of treatment can be further amplified by the use of silvol, 5 per cent. solution, in the same

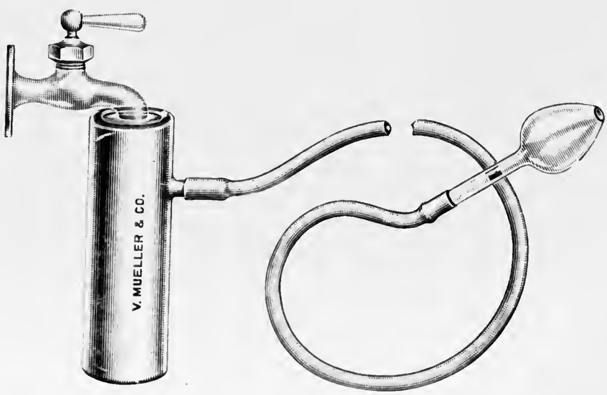


Fig. 223.—Beck's suction apparatus.

manner as described in the use of the adrenalin solution. These treatments, namely, adrenalin, suction and silvol, should be carried out three or four times a day at home until symptoms have subsided, when the treatment is gradually discontinued. In case of severe pain over the region of the antrum, with definite symptoms of involvement of that sinus, it may become necessary to puncture the sinus through the nose in the inferior meatus. However, it should be borne in mind to do as little surgically within the nose during an acute process as possible, owing to the great danger of secondary infection of the meninges. All kinds of soundings and probing of the sinuses should be avoided for the same reason. The writer has seen several cases of local or general meningitis, in consultation, following just such irrational and dangerous treatment. (The technic of antral puncture will be described later.) During the acute suppurative process it is well to determine the bacteriological findings and preserve a culture to the extent of subculturing, and if the patient does not make an uneventful recovery, say within three weeks' time, then have an autogenous vaccine made and employed according to the accepted method of vaccine therapy. In the treatment of chronic suppurative sinuses, and we may say that with the exception of the antrum infection of dental origin, all of the sinuses on one side are usually involved at the same time. At any rate the anterior group, that is, the frontal, anterior ethmoid cells and antrum, are, and later the posterior group, that is the posterior ethmoid cells and sphenoid sinuses. The writer has for years followed about the same surgical procedures in sequence as will be described, unless there were some special reasons to deviate from them.

1. Removal of middle turbinated body, breaking down and curetting both the anterior and posterior ethmoidal cells, passing sounds into the frontal, antrum and sphenoid sinuses through their natural openings without attacking any part of the sinus itself.

2. If following this procedure and adequate after-treatment the symptoms still persist or progress, then the openings of the channels leading to these sinuses are enlarged as, for instance, taking off part of the wall of the nasofrontal duct, nasal wall of the antrum at the middle meatus or anterior and anterolateral wall of the sphenoid sinus. In case that one or all of the sinuses still continue either to suppurate or are blocked by pathological tissues, then more radical measures become necessary, as will be described in the technic.

Technic.—Middle turbinectomy, ethmoidal exenteration and sinus exploration.

Local Anesthesia.—Patient placed in a semirecumbent position, as in the septum operation. The same technic of cocainization, except that the application is made directly under and above the middle turbinated body.

Steps of Operation.—1. By means of Finger forceps (Fig. 220) the threaded Michel clip is applied to the anterior extremity of the middle turbinated body (Fig. 224).

2. The attachment of the middle turbinated body to the lateral ethmoid mass is severed from before backward by means of the writer's conchotome as far as two-thirds of its extent (Fig. 224).

3. Without removing the instrument, when this cut has been com-

pleted, the remains of the attachment of the middle turbinate are broken off by bearing down on the conchotome. This procedure will cause the middle turbinated to be dislodged into the inferior meatus, hanging on by the remains of its membranous attachment.

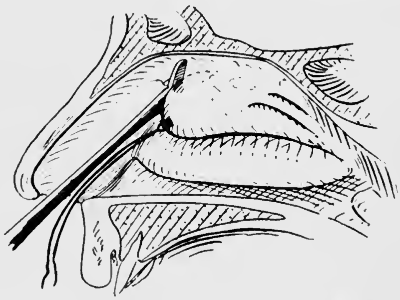


Fig. 224.

4. The thread of the Michel clip is passed through the Krause nasal snare (Fig. 225), which in turn is passed about the severed middle turbinal. This maneuver is facilitated by slight traction on the thread while an assistant is holding the nostril open by a medium long nasal

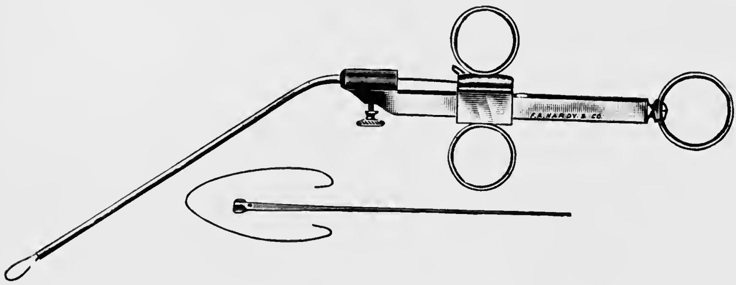


Fig. 225.—Krause's nasal snare.

speculum (Fig. 200). Drawing down the wire will sever this membranous attachment, and by the aid of the thread it is removed *in toto,* preventing it from dropping back into the throat, which is a very disagreeable accident.

Fig. 226.—Greenwald's ethmoid punch

5. The ethmoid cells are entered anteriorly by means of a small punch (Fig. 226), making two or three bites (Fig. 227).

6. This instrument is immediately replaced by a curette which continues backward, breaking down one cell after another (Fig. 228),

until the last ethmoidal cell is reached (Fig. 229). This can be determined by a slight percussion with the curette, by the sound and touch of harder bone. The curette now removes the remaining lateral cells situated along the entire length of the orbital plate of the ethmoid, known as the lamina papyracea. Care should be taken not to use too much pressure here, otherwise one might open into the orbit.

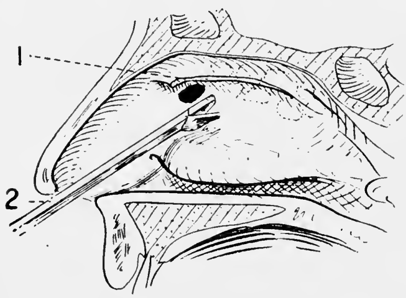


FIG. 227.—1, cut edge of middle turbinate; 2, punch.

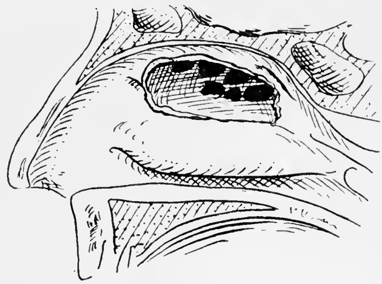


FIG. 228.

A greater danger in this operation is the possibility of getting the curette into the olfactory fissure and causing such trauma as to produce infection through the cribriform plate of the ethmoid, thus opening the lymph spaces for a possible meningitis. One must remember never to go farther in toward the septum in this curettage than the line of severance where the middle turbinate was attached.

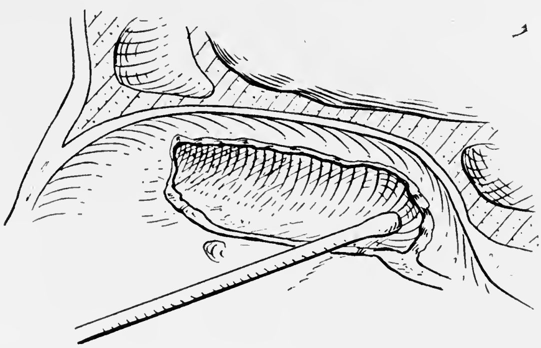


FIG. 229.

7. *Sounding of the Sinuses.*—The frontal sinus is usually easily sounded unless pathological processes, especially in the bony structures entering into the formation of the nasofrontal duct, have taken place. Having a lateral view x-ray picture of the head will aid the passing of such a sound. Force should never be employed in this procedure and the posterior wall of the frontal sinus must be constantly borne in mind to avoid injuring same. The sounds that are employed are

graduated in size (Fig. 230) and one should attempt to pass the largest first. They are so curved that when the point of the sound has entered the cavity of the sinus the flat of the handle rests on the upper lip (Fig. 231).

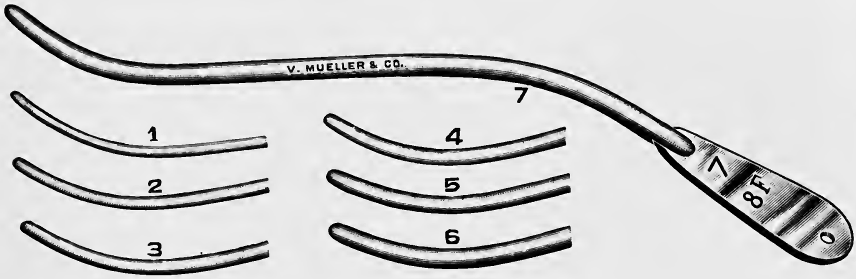


Fig. 230.—Ritter's frontal sinus nasal sound.

In passing the sound into the antrum the same instrument is employed. Locating the thinnest part of the middle meatus with the point of the sound, one will usually drop right into the antrum, with but a slight pressure. The flat of the handle of the sound is directed toward the septum. The largest sound of the four is usually chosen and passes without any difficulty. Whether it is the natural opening of the antrum that is sounded, the accessory or artificial one, cannot

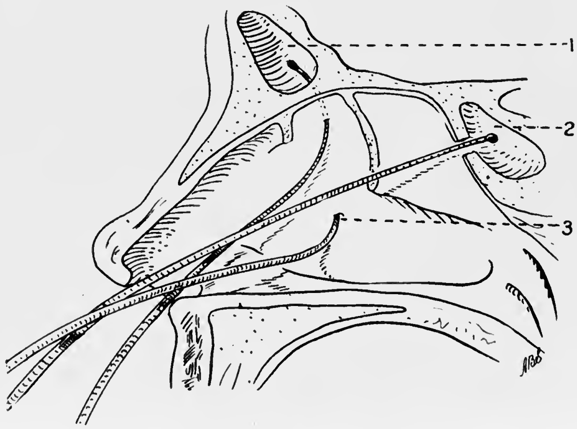


Fig. 231.—1, frontal sinus; 2, sphenoidal sinus; 3, maxillary sinus.

be determined, and does not make any difference. The sphenoid sinus is also comparatively easy to sound, especially when the middle turbinate body has been properly removed. The writer has devised a set of three spear-shaped sounds (Fig. 232) for this purpose. The direction of passing the sound is up and backward at an angle of about 45 degrees to the floor of the nose. With the spear point at that location a fairly firm pressure is exerted when, as a rule, the sound passes into the sphenoid sinus. The shaft of the sound is not rigid and will bend when more pressure is exerted than is safe. The spear is flat, corresponding to the direction of the flat bottom of the handle.

In withdrawing the sound one should turn the button 90 degrees, which will engage the shoulders of the spear against the margins of the opening of the sinus, and thus will enlarge it considerably. Subsequent sounding of the sphenoid is carried out by a small olive-tipped sound with a rigid shank.

8. Packing is usually unnecessary; in fact, it is to be avoided if possible, since retention and secondary infection of the sinuses and Eustachian tubes is liable to take place. Should the bleeding, however, be too brisk and with no tendency to stop, then a packing may be necessary. In such cases it should only be packed moderately firmly, with folded strips of gauze confined to the upper portion of the nose. To keep it in that position the writer puts into the inferior meatus a fairly firm rubber tube, thus permitting some nasal breathing.

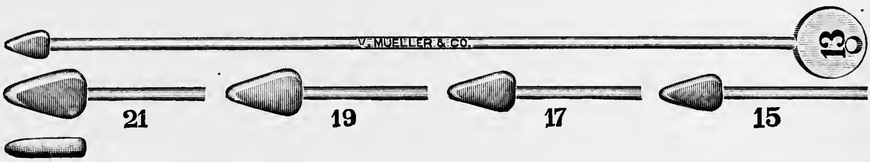


Fig. 232.—Beck's sphenoid sounds.

After-treatment.—If packing has been used it should be removed the next day. If not then there should be absolutely no disturbance of the wounded surfaces. No irrigations or swabbing, with or without medicaments. Rest in bed or in a chair is advisable for two or three days. There is usually considerable reaction and blockage of the nose, which should be treated with the greatest of gentleness. Application of vaselin from a collapsible tube or the instillation of a few drops of adrenalin solution is about the limit of treatment.

Immediately after operation the patient is to be warned against blowing the nose at all, and the next day only very moderately, owing to danger of forcing air into the orbit and cellular tissue about the lids, in case of perforation of the lamina, or in cases in which there is a dehiscence from disease. Forced nasal breathing exercises are to be encouraged a day or two after operation.

Three or four days after operation one may remove mechanically the crusts that are not easily blown out by the patient, and he is given instructions how to employ silvol for home treatment, as described on page 492. Vaselin from a collapsible tube is also employed until all wounded surfaces have healed, which is usually at the end of two weeks. In the subsequent visits (once a week) the sounds are passed into the various sinuses. Should the retention of pus be discovered in any of them, then these are washed out by means of a washing apparatus (Fig. 222), employing normal saline or weak bicarbonate of soda solution. The use of suction and vaccines, as described on page 492, are also to be employed in conjunction with the procedure already suggested.

Course.—This line of treatment is to be continued for a period of two or three months, providing there is observed a constant improvement. If, on the other hand, the process is at a standstill, or probably worse, one will have to decide on a more radical procedure, which the writer will discuss separately under each sinus. In cases of lues or tuberculosis the condition is usually in the form of pan-sinusitis and marked changes in the bones, including the hard palate and septum.

Frontal Sinus.—To enlarge the nasofrontal duct it has been the custom of the writer to adopt the suggestion of Mosher, to follow the anterior ethmoidal region toward the floor of the frontal sinus and open into it. That procedure removed the posterolateral boundary of the nasofrontal duct without disturbing the great circumference of the channel and prevents secondary occlusion by granulation tissue, which follows when one reverses the method and attempts to remove the anterolateral portion of the duct. In this later procedure one must remove much denser bone (internal nasal spine), which reacts much more actively and soon after operation causes greater obstruction than before operation. Following the Mosher procedure, one employs the largest frontal sinus probe for several weeks, when it finally will remain open, drain and ventilate the frontal sinus very satisfactorily in a fair number of cases. Yet there will be some that will not respond to that treatment. In these cases one may choose between the *osteoplastic method* of the writer or the *Lothrop operation.* Both of these are external operations, having much the same advantages, in preventing deformity and retaining a patent frontal sinus. The advantages of the writer's method over the Lothrop is its complete exposure of both sinuses to inspection. The Lothrop operation is a more radical procedure and offers a permanent cure and prevents retention.

Beck's Osteoplastic Operation.—Permit me now to briefly describe the procedure which I recommended eight years ago as an external non-obliterating operation in those cases that are unsatisfactory after an intranasal procedure. I might say that I have had to change but one item in the technic since I first presented it, and that is the avoidance of the destruction of the lining membrane of the internal nasal crest.

Steps of Operation.—1. Roentgenogram, postero-anterior for proper anatomical outlines (Fig. 233).

2. Celluloid model made from tracing of frontal sinus from roentgenogram (Fig. 234).

3. Incision through skin and subcutaneous tissue along the upper margins of the eyebrows, and these united across the bridge of the nose (Fig. 235).

4. Dissection of the skin and subcutaneous tissue flap upward and placing of celluloid model over exposed area (Fig. 236).

5. Incision through the periosteum along the margin of the celluloid model (Fig. 237).

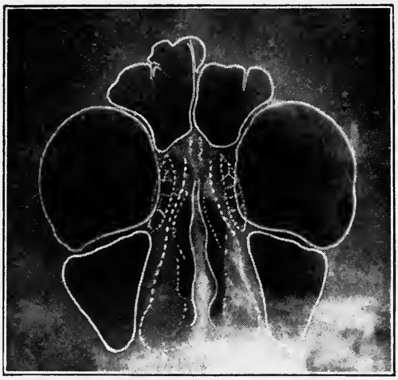


FIG. 233.—Roentgenogram with outlined sinus.

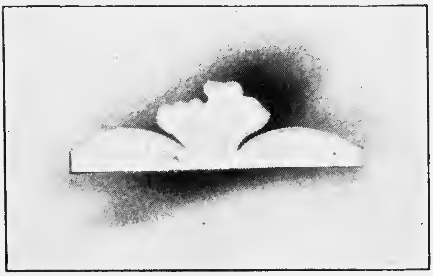


FIG. 234.—Celluloid model of size and shape of frontal sinus with supra-orbital margins as landmarks.

FIG. 235.—Incision just below or above margin of eyebrow, down on side of nose and united with opposite incision across the bridge.

6. Chisel and burr along this lateral periosteal incision from one supra-orbital margin to the other into the interior of the frontal sinus (Fig. 238).

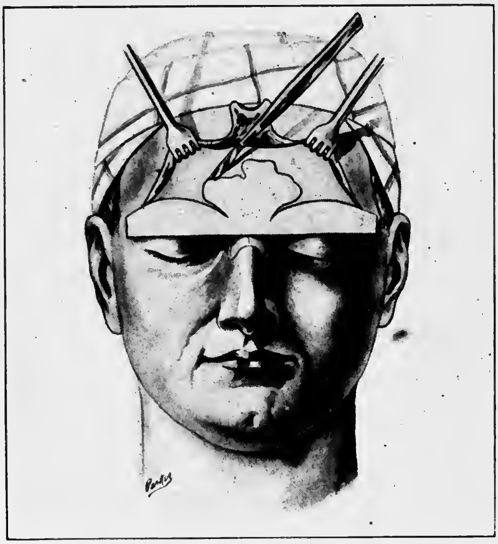


Fig. 236.—Skin and subcutaneous tissue dissected and retracted as far as possible. The incision over eyebrow should be extended outward as far as necessary in each individual case depending on size of sinus. The celluloid model in place and knife incising periosteum all about the margins of the model of the outline of the frontal sinus (not the supra-orbital landmarks of model).

Fig. 237.—Incision of periosteum completed.

7. Gigli saw engaged in the upper edge of this incision and brought down to the level of the supra-orbital margin, thus cutting the septum

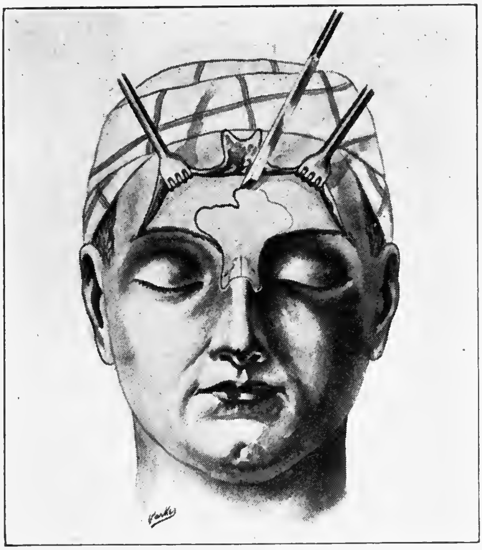


FIG. 238.—Chiselling in a beveled fashion into the sinus along the periosteal incision.

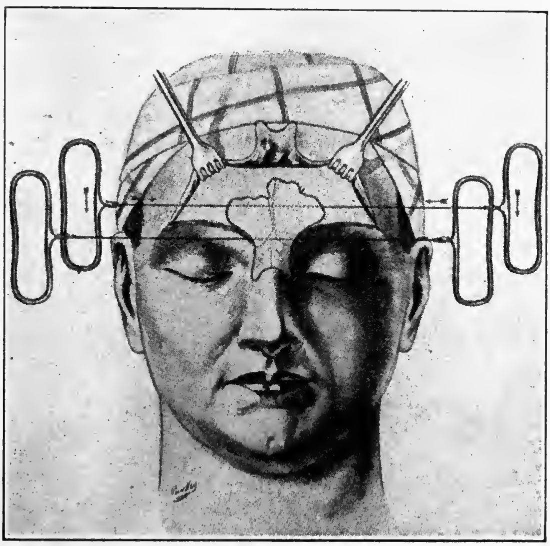


FIG. 239.—Gigli saw introduced at upper margin of the sinus and sawing downward until supra-orbital margin is reached, then drawing saw slightly forward until root of nose, but not completely through the bone, thus leaving a pedicle.

of the frontal sinus, then saw directed slightly upward to weaken the osteoperiosteal pedicle (Fig. 239).

8. Turning this osteoplastic flap down, removing the pathological tissue, but carefully avoiding exposure of bone to any great extent (Fig. 240).

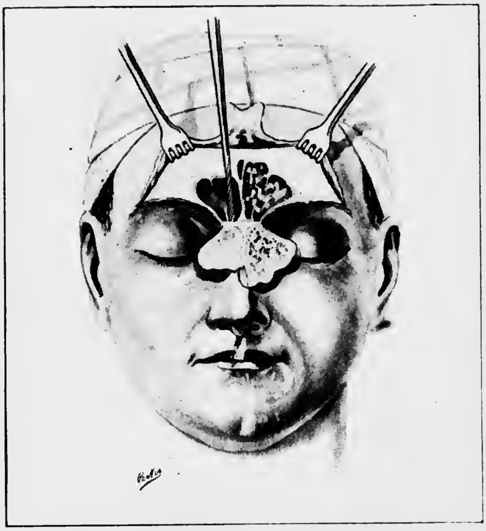


FIG. 240.—The anterior wall (osteoperiosteal flap) turned down over the nose, showing one side with the disease and the other side already cleansed. An electrically or hand-driven burr, enlarging the frontal sinus outlet in action.

9. Enlarging outlet of the sinus in the nose, backward and outward, by means of an electrically driven burr (Fig. 240), carefully avoiding the internal nasal crest by use of the Halle protector (Fig. 241).

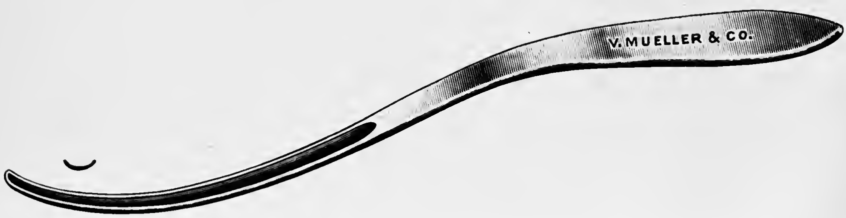


FIG. 241.—Halle cranial protector.

10. Semisolid rubber tubing inserted into the outlet, one end coming out at or near the nostril, the upper end at the beginning of the outlet of the frontal sinus or infundibulum. Through this tube a strip of gauze is packed, the upper end loosely filling in the cavity of the sinus (Fig. 242).

11. Osteoplastic flap brought back into position and the skin and subcutaneous tissue flaps brought down and sutured or closed by use of clips.

After-treatment.—On the second day remove the gauze and on the fifth day the tube. No further drainage is necessary. Subsequently, but not before three weeks, wash the sinus with normal salt solution or injection of bismuth paste into the sinus may be done.

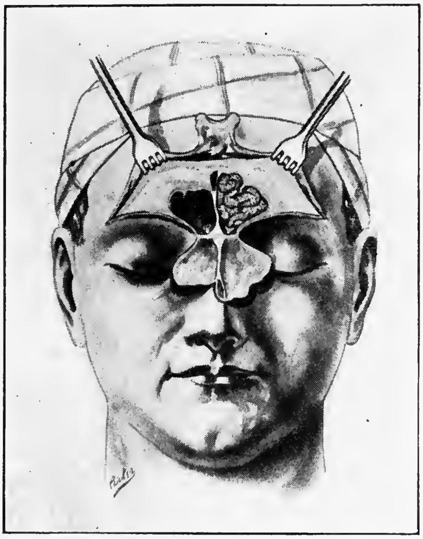


Fig. 242.—In one side the rubber tube without gauze and the other loosely packed with gauze, the end passing within the rubber tube into nose.

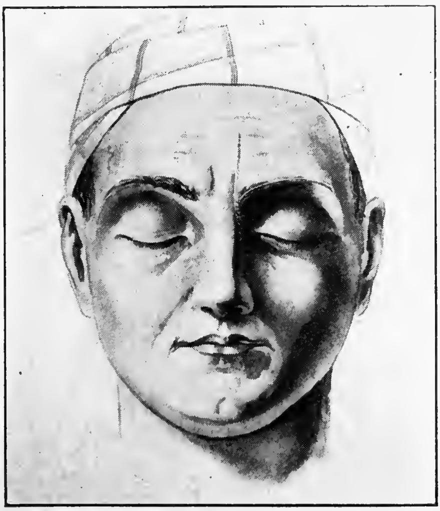


Fig. 243.—Incision for unilateral operation. In such cases the osteoperiosteal flap is made either by the aid of a chisel or fine electric burr and the small bony pedicle broken over. The skin and subcutaneous incision may be made the same as in the double operation, but the advantage of opening only one side when only one side is involved is obvious.

In criticism of the procedure I would say that if only one side is affected one may take off just the one-half of the anterior surface of the sinus, that is, employ the fine burr or chisel to follow a celluloid model of just the size of the sinus to be exposed (Fig. 243). This is an objection in that one may infect the otherwise healthy sinus. I have no doubt that I have done this very thing several times without any untoward results, because the procedure cured the infected sinus, and thus prevented reinfecting the healthy sinus to any extent. As to exact statistics, I will state that since 1908 I have performed this operation thirty-one times, with an apparent cure in 27 cases. On two occasions I operated away from home and never heard whether the results were satisfactory or not; the other two sinuses had to be reoperated by the Killian method. These were the early cases in which I made large openings into the nose, taking away some of the internal nasal crest, and in which the mucous membrane of the entire circumference of the outlet of the frontal sinus was destroyed. These reoperations would have been good cases for the Lothrop operation.

Fig. 244.

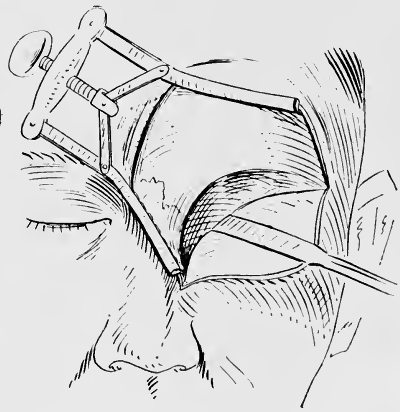


Fig. 245.

Lothrop Operation.—The principles involved in the technic are to convert both frontal sinuses into one cavity by taking away the septum between the sinuses, to continue the removal of the septum of the nose at the root of the nose, and a bit farther down. Thus one may, after the operation, pass sounds from the right side of the nose into the left frontal sinus, or *vice versa*, which are now one (Fig. 249). The resulting opening becomes subsequently covered with healthy mucous membrane, and can never close, because it is too large to become approximated.

Technic.—Operation may be performed under either local or general anesthesia.

1. An incision one and one-half inches long at the inner corner of the eye, at the junction of the nose, down to the bone (Fig. 244). Do not go through eyebrow.

2. Dissect off periosteum in both directions and introduce self-retaining speculum (Fig. 245).

3. By the aid of an electrically driven burr, take away a plate of bone (gouges, chisels and bone forceps may also be employed), about the size of a dime at the upper inner angle of orbit (Fig. 246).

4. A small oval burr takes down the interfrontal sinus septum.

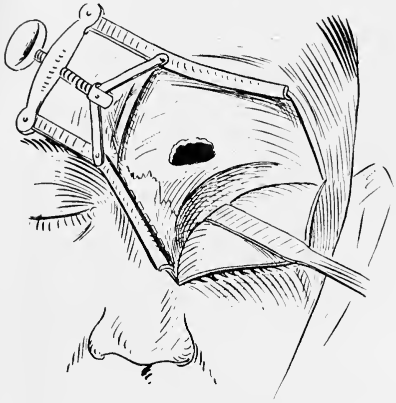


Fig. 246.

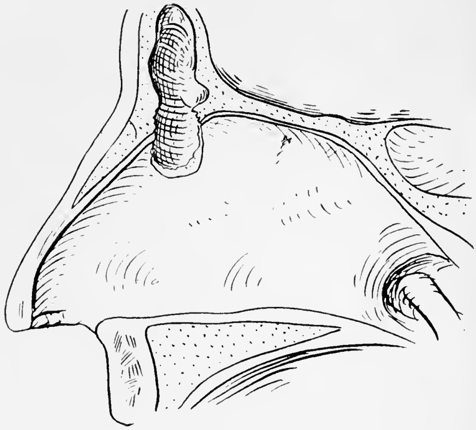


Fig. 247.

Fig. 248.

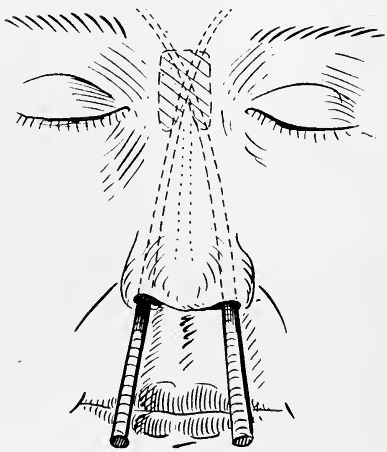


Fig. 249.

5. With a heavier oval burr remove, by way of the external opening and through the nose, the thick nasal spine of the frontal bone and the perpendicular plate of the ethmoid (septum), taking great care to keep well to the front, toward the nasal bones, and avoiding injury of the cribriform plate of the ethmoid (Figs. 247 and 248).

6. Close the wound by primary suture.

After-treatment.—For the next week there is practically nothing to do except the removal of the stitches. The edema of the lids requires no special attention. When the acute symptoms of the operation have disappeared then the frontal sinus should be probed from either side of the nose until the wound has healed by a mucous membrane covering (Fig. 249).

Radical Frontal Sinus Operation (Killian).—There will still remain a fair number of cases of chronic frontal sinus disease that will not recover following the operative procedures just described, or there may be such marked progress in the pathological changes of the sinus to begin with, that the radical operation must be performed. The principles underlying this operation are: (*a*) Complete obliteration of the cavity, with the least amount of deformity possible. The first procedure can always be accomplished, but the second will depend upon the size of the sinus, both laterally as well as its depth. It is very important that the supraorbital border, known in the operation as the bridge, should be well preserved, and yet if too much of the bone is retained it may defeat the purpose of the operation.

Fig. 250.

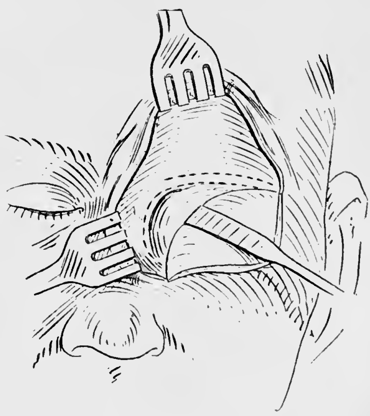


Fig. 251.

Technic.—Usual external preparation of the field. Do not shave the eyebrows. Either local or general anesthesia may be employed.

1. Incision above or below the eyebrow, but not through it, and continued down the side of the nose. Ligate the supra-orbital vessels (Fig. 250). If below the eyebrow there will be a more restricted field and more difficulty in exposure, especially in a large frontal sinus.

2. Dissect all tissues with periosteum until the greater part of the anterior surface of the sinus is exposed, and retract forcibly. The retraction should be forward rather than upward and the subsequent removal of bone is performed in a sort of a pocket (Fig. 251). The reason for this is the limited incision. The orbital contents at the internal canthus are dissected downward and held by a retractor.

3. By the aid of an electrically driven burr (ball) the entire anterior bony wall of the sinus as well as the floor are removed, leaving a strip of bone (supraorbital border) about one-eighth of an inch in thickness (Fig. 252). There is no danger of its being fractured, since the orbital plate of the frontal bone is not attacked in as great an extent as it formerly was in this operation.

4. The entire lining membrane of the sinus is thoroughly removed by a curette, and subsequently the burr plays lightly over the surface so as to hasten the formation of granulations, and thus causing obliteration. The mucous membrane should be thoroughly removed from the infundibulum toward the nose, so as to prevent retention in that portion of the nose.

5. After primary suture of the incision the tissues are firmly pressed into the cavity and a firm pressure bandage is applied.

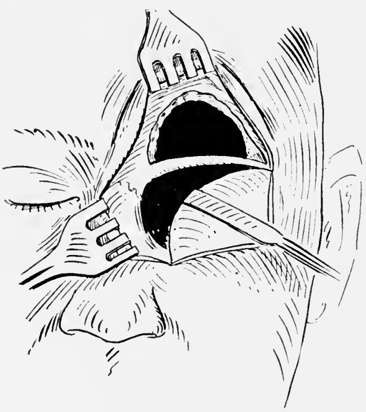


Fig. 252.

Fig. 253.

After-treatment.—There is usually nothing to do for the first week except to remove the stitches. After the bandage is removed the patient should be warned against forcibly blowing the nose, thus avoiding getting the secretions into the cavity and preventing obliteration. In case the deformity resulting from the obliteration be too large, especially if both sinuses had to be operated upon, there can and should be performed a plastic operation to correct this deformity. This should not be done until one is certain that the obliteration is complete and the area is sterile. The best results in these cases have been from the use of fat and fascia from abdomen or leg. Never paraffin or any other foreign substances.

Antrum of Highmore.—There are many more methods of operating on the antrum than upon any other sinus, but several of these have fallen into disrepute and the others are more or less modifications, consequently the writer will confine himself to the description of operative procedures that to him appear the most practical and the ones employed routinely by him. There are two ways of attack:

1. By way of the nose.
2. Under the lip.

The majority of rhinologists prefer the nasal route, however, everyone admits that the method under the lip offers the best chance of inspection and properly opens into the nose.

Fig. 254.

Technic.—Intranasal route. 1. Local applications of cocain, as in other intranasal operations. By hypodermic injections of 1 per cent. apothesin the anterior surface of the superior surface of the superior maxilla (periosteum) is anesthetized (Fig. 254), as is also the inferior meatus (Fig. 255).

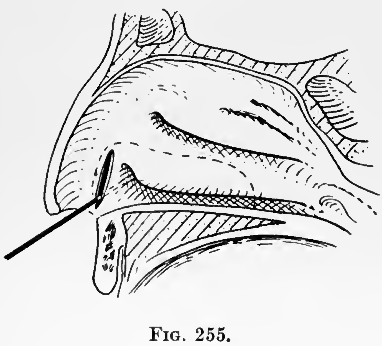


Fig. 255.

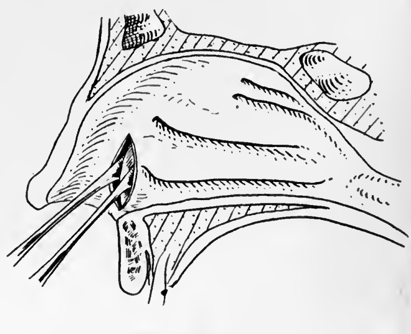


Fig. 256.

2. Incision within the vestibule over the bony edge of the superior maxilla (aperatura pyriformæ) (Fig. 255).

3. Periosteal elevation lifting off the mucoperichondrium of the inferior meatus and an immediate introduction of a right angular flat retractor (Figs. 256 and 257).

4. Elevation of the periosteum over the anterior surface of the superior maxilla for a distance of one and one-half inches. A similar

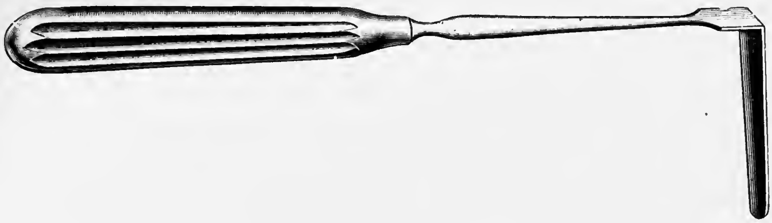


FIG. 257.—Freer's long retractor.

retractor introduced into this wound. Forcible retraction on these two retractors will expose the part of the superior maxilla to be attacked (Fig. 258).

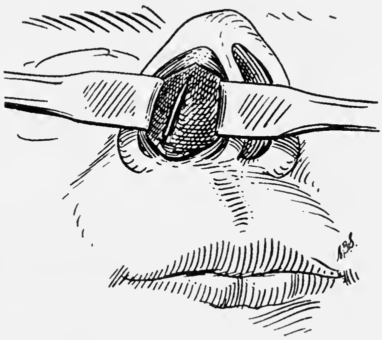


FIG. 258.

5. By the aid of a burr, chisel and rongeurs (Fig. 259) a piece of bone, one-half inch in diameter, is removed, giving a very good inspection of the antral cavity.

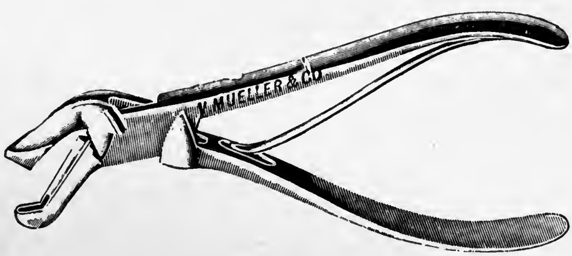


FIG. 259.—Lombard bone forceps.

6. By the aid of a nasal forceps (Fig. 206) some of the bone of the nasal wall of the antrum (inferior meatus) is further removed for about one-quarter of an inch.

7. The parts are allowed to fall together and a fairly stiff rubber tube, one-quarter of an inch in diameter and about one inch long, is passed into the antrum and allowed to protrude from the nostril. This tube should remain in place for about forty-eight hours, when the opening into the antrum will be established and remain.

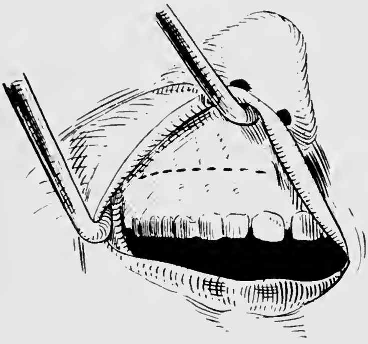


Fig. 260.

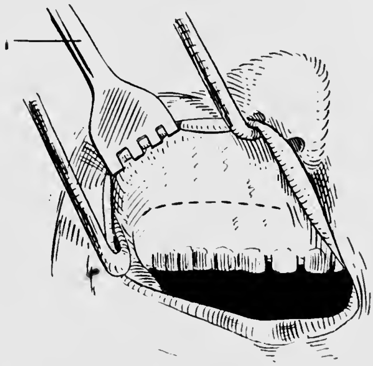


Fig. 261.—Second retractor in place.

Sublabial Operation.—1. Incision from the center to the first molar tooth through the mucous membrane underlying tissues (Fig. 260). This incision should not be made in the gingival tissues but farther back, since suturing is thus facilitated and more rapid healing is obtained.

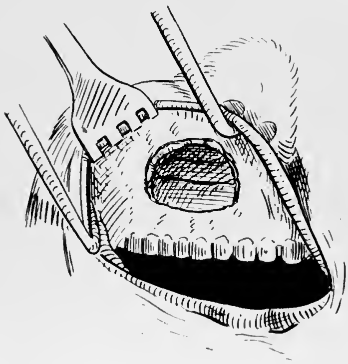


Fig. 262.

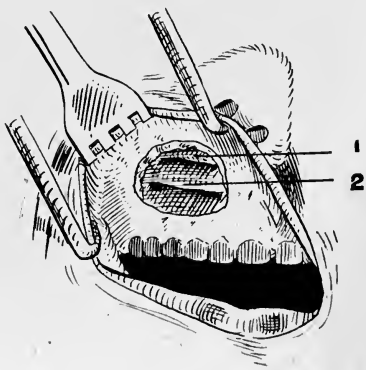


Fig. 263.—1, middle turbinated; 2, inferior turbinated.

2. Firm traction forward rather than upward (as in the Killian operation), by means of a second retractor exposing the anterior surface of the superior maxilla (canine fossa) (Fig. 261).

3. Removal of a piece of bone either by burr or gouges and rongeurs as large as a nickel (Fig. 262).

4. If there are polypi or other diseased tissues present they should be carefully removed without sacrificing the linings of the cavity.

5. Over the prominent portion of the inferior meatus, well forward, a piece of bone is removed the size of a dime (Fig. 263). The mucous membrane lining the nose over this bony area just removed should be saved, if possible, and utilized to fold over the lower edge of the bony incision of this inferior meatal opening just made.

6. A rubber tube similar to the one employed in the intranasal method is passed through the naso-antral wall, out through the nostril (Fig. 264).

7. The wound sublabially is completely closed by three or four interrupted sutures.

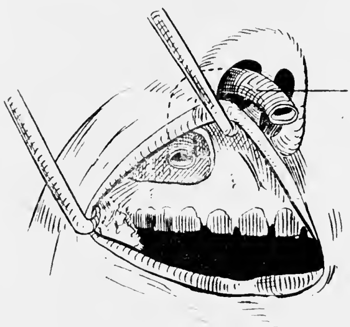


FIG. 264.—1, drainage tube.

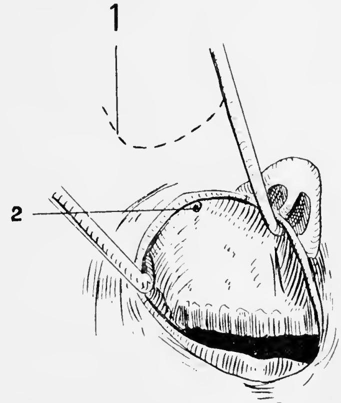


FIG. 265.—1, infraorbital margin; 2, infraorbital foramen.

After-treatment.—The tube is removed after forty-eight hours by way of the nose, and the stitches in about four days.

In only a small proportion of cases in which either of these operations has been performed will there remain symptoms of antrum disease severe enough to require more radical measures, as was true in the frontal sinus. The writer has developed a technic of obliterating the antrum without necessarily resorting to the deforming operations advocated by Shede or Jansen.

Beck's Obliteration Operation.—*Technic.*—1. Expose the entire anterior and lateral portion of the superior maxilla through the sublabial route. This requires severing the cartilaginous attachment of the nose on one side from the apertura pyriformæ (Fig. 265).

2. Find the infraorbital foramen and nerve.

3 Inject the infraorbital nerve by means of cocaine, 4 per cent. (novocain or apothesin will not suffice), and remove the nerve by neurectasis.

4. Remove the greater portion of the anterior and lateral portion of the superior maxilla, in other words, the two walls of the antrum (Fig. 266).

5. Remove thoroughly all the mucous membrane of the antrum.

6. By the aid of the burr remove the superficial layers of the bone of the remaining surfaces of the antrum, to promote granulation formation.

7. Remove the greater portion of the naso-antral wall of the inferior meatus, including the mucous membrane, if that had not been done before.

8. Closure of subliabial incision by six interrupted stitches.

9. A firm ball of cotton, about the size of a small apple, is placed over the anterior lateral surface of the face and a firm bandage applied, thus aiding obliteration. This bandage is left on for several days.

After-treatment.—Remove the stitches in four or five days. After about ten days begin to inject bismuth paste into the remaining cavity, not obliterated by the soft tissues overlying the antrum. These injections are carried out through the inferior meatal opening, about three times a week, until the cavity is entirely obliterated, which may take from one to six months, depending upon the size of the cavity.

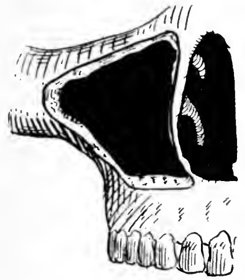


Fig. 266.

Ethmoidal Labyrinth.—In case the primary intranasal exenteration of all these ethmoidal cells is not followed by the cessation of discharge, one will have to think of one or both of the following conditions:

1. That there are still some cells which have not been opened for proper drainage and ventilation, or the disease is of a serious pathological nature as, for instance, a necrotic process of pyogenic, luetic or tuberculous etiology. In the event of the former condition one will reoperate even more than once, until finally the process is brought to a standstill. This can be done intranasally, since there are very few ethmoid cells that cannot be reached by that route with safety.

2. In the presence of a persistent suppurative process the same is more likely to be due to a bone disease. Then appropriate attention should clear up the condition in time. Some of the most brilliant results in arresting the discharge are in luetic cases. Blood examination is frequently negative as to the Wassermann reaction. The use of the mercury or KI treatment may have been of little value whereas salvarsan acts wonderfully well.

Sphenoid Sinus.—This cavity, as a rule, responds very favorably to surgical treatment by simple opening, ventilating and draining. However, like the rest of the sinuses, there are times when more active surgery or treatment is necessary to bring about resolution or cessation of discharge. One of the reasons for this difficulty is the unusual anatomical malformation or extension that exists at times. Prentiss, of the Iowa University, anatomical department, has shown in a fair number of specimens the extensions of the sphenoid sinus occur deep down and back toward the clivus and in the direction of the pterygoid plates, also laterally into the wings of the sphenoid.

Operation.—The more extensive procedure is to remove the greater part of the anterolateral wall well into the posterior ethmoid region. This is accomplished by any of a variety of the sphenoidal punches. There is one precautionary measure in the removal of the anterolateral wall, and that is to guard against the injuring of the sphenopalatine artery, which lies laterally and very much lower than one is ordinarily called upon to extend the incision. Only in those anomalous cases mentioned before, in which one would like to follow the process and explore it, is there much danger of wounding this artery. In case of injury of this artery, its control is, as a rule, possible by firm nasal packing.

Whenever the disease is of osteal rather than membranous nature, or both, like a rarefied osteitis of septic, leutic or tuberculous etiology, one has recourse to non-surgical measures. These conditions are usually of severe form, in that great pain (in the head) is present, accompanied usually by ocular symptoms referable to the optic, motor and sympathetic nerves. To determine that the bone is soft, one can employ a diagnostic symptom, original with the writer, who has demonstrated its value in about half a dozen cases of this type. While one inspects the sphenoid sinus area, an assistant compresses both internal jugular veins and carotid arteries along the sternocleidomastoid muscles. There will be observed at first a pulsation and soon after an outpouring of pus, due to the distention of the internal carotid arteries and cavernous sinuses situated in close proximity of the sphenoidal sinus.

THE PHARYNX.

Anatomically the pharynx is divided into:

A. Nasopharynx or postnasal space, better still, epipharynx.

B. Oropharynx or pharyngeal space proper, better still, mesopharynx.

C. Epipharynx, region of the base of the tongue, better still, hypopharynx (Fig. 267).

Epipharynx.—Structures to be considered from the surgical point of view in the epipharynx are the adenoid tissues at the vault, usually spoken of as adenoid vegetations and the pharyngeal ends of the Eustachian tubes. Extension of pathological processes from the nose, particularly the sphenoid cavity, and extension downward from the hypophysis must also be borne in mind.

The consideration of the adenoid disease will be taken up, together with tonsillar affections, since the surgical treatment of both of these is usually carried out simultaneously.

Tumors.—Occasionally one meets with tumors, one of the most frequent affections confined to the epipharynx. The origins of these are either from the vault in the region of the adenoid or laterally from the wall of the sphenoid sinus. These tumors are of comparatively slow growth, cause very few early symptoms. At first there may be an interference with nasal respiration of one or both nostrils, and a change in the voice by a sort of a dead tone or a nasal obstructive twang. Pain radiating to the side of the head and face often follows. Patients usually experience difficulty in hearing on the side, when the tumor encroaches upon the Eustachian orifice, and complaints of very severe noise (tinnitus) are not at all uncommon. Inspection usually reveals a limited motion up and back of the soft palate, in saying—"ah" or upon reflex action when touching the soft palate.

Postrhinoscopic examination, with a mirror, as well as direct examination through a thoroughly shrunken nostril, will reveal the tumor. Palpation with the finger, postnasally as well as directly against the soft palate, will reveal the consistency, location and size of the growth as well as to whether it pulsates, bleeds or is painful. The pathological condition most frequently found is that of fibrosarcoma. Abscesses, aneurysm or carcinoma are much less frequently met with in the epipharynx.

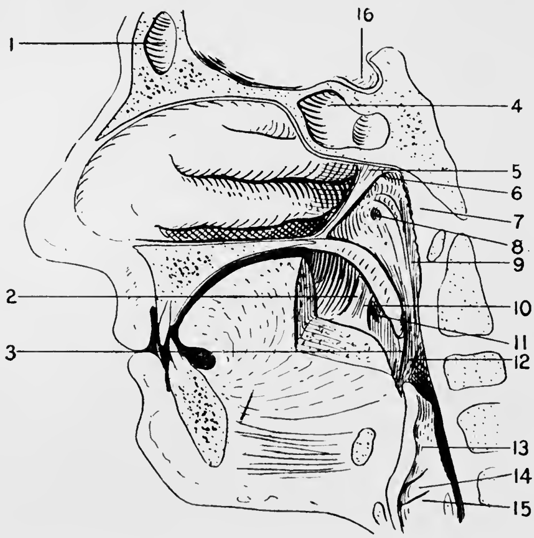


FIG. 267.—1, frontal sinus; 2, ant. pillar; 3, post. pillar; 4, sphenoidal sinus; 5, post. edge of nasal septum; 6, fossa of Rosenmüller; 7, pharyngeal tonsil; 8, Eustachian tube; 16, hypophysis.

Treatment.—The treatment giving the best results is, of course, the surgical. The greatest difficulty has been the firmness with which these tumors are attached and the severe hemorrhage that results immediately at the severance of the growth from its attachments.

Technic.—Cocainizing by topical applications of pure cocaine flakes, as well as the peripheral injection of the tumor, of a 1 per cent. solution of cocaine, will usually suffice. The patient is best placed in a semi-reclining position on a table and a suction apparatus at hand to remove the blood and secretion, so that the patient needs to make no effort in clearing the throat.

1. Pass a small rubber urethral catheter through each nostril, which has also been cocainized, and withdraw the ends through the mouth (Fig. 268). This is for the purpose of drawing the soft palate forward and obtaining a very clear view of the epipharynx.

2. By means of a full, curved, strong scissors the growth is severed from its firm attachment and the free flow of blood is sucked up, and then with a full, curved, artery forceps, grasp the bleeding points.

3. Grasping the partially severed tumor by a strong vulsellum, a very heavy wire snare loop is passed around the greater circumference of the tumor and removed with the aid of the snare. It is not at all infrequent that the wire breaks or slips out of the snare, owing to the firmness of the tumor.

4. It is well to have at hand a galvanocautery, so that any mass remaining may be destroyed by that method.

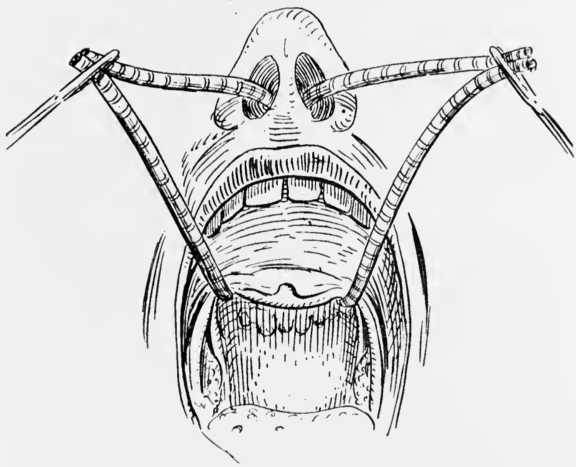


Fig. 268.

5. Should bleeding be very profuse and not controlled by the method mentioned, then a very firm, postnasal tampon must be introduced. This is very easily done by attaching the ends of a piece of tape, which holds the tampon to each end of the rubber catheter, which are withdrawn through the nose.

After-treatment.—If a tampon has been employed then it should be removed on the next day, but often it is necessary to reintroduce a less firm one, because oozing may start up again.

The raw surface takes several days to heal and the application of silvol by way of the nose is the best method of medication.

Beck's Technic. — Tilt the head well back, preferably over the edge of the bed or back of a chair, and allow about two medicine dropperfuls of silvol, 5 per cent., to trickle slowly into the nasopharynx, until the patient feels it escaping lower down into the throat. Remaining in this position for one or two minutes the head is brought into the extreme opposite position (forward and downward) for about ten seconds (Fig. 269). Repeating this procedure about

Fig. 269.

one-half dozen times a day will aid in the healing of the large raw surface. Silver nitrate, full strength or fused on a probe as a bead applied to the actual granulation, may become necessary.

Radium Treatment.—This may be applied without any previous operative procedure or after the greater part of the growth has been removed.

Technic.—Cocainize and retract the palate as if about to operate.

1. The use of platinum needles, each containing $12\frac{1}{2}$ mlgrs. of radium element, are pushed into the tumor from three to five directions. From $37\frac{1}{2}$ to $62\frac{1}{2}$ mlgrs. of radium are thus inserted within the growth.
2. Allow this to remain from four to eight hours, depending upon the nature of the histological pathology—if fibrosarcoma, four hours; if myxosarcoma, six to eight hours.
3. *After-treatment.*—The reaction from radium should receive the same attention as that following operations, namely, silvol by way of the nose.

The entire growth is seldom destroyed by one application. As a matter of experience and from reference to the literature one learns that it may take as many as six seances before the entire growth is destroyed. The repetition of the treatment depends on the amount of reaction resulting from the previous application. Usually, however, within two weeks the necrotic surface will clear up and the marked reaction disappear. If the growth has been operated upon, and it is desired to use the radium to follow up the surgical intervention, then it is best to employ the radium in capsules. These are placed within a rubber tube and drawn back, as one would the postnasal tampon, to control hemorrhage. One must see clearly that the tube containing the radium is in close contact with the raw surface. The same dosage is employed as in the needles, but it is allowed to remain longer because the capsules are usually covered with a thicker filter. In the few cases treated by the writer he permitted the capsules to remain overnight. This postoperative treatment with radium should not be started until all oozing has stopped and the necrotic surface cleaned off.

Nasal Polypi.—Particularly from the sphenoid sinus or posterior ethmoid cells do we find a solitary polyp reaching into the postnasal space and there develops to a much larger size than it does within the nasal cavity. Examination with the postrhinoscopic mirror will show it to be grayish in appearance and palpation finds it to be freely movable and very soft.

Treatment.—It is best attacked by way of the nasal cavity, combined with the pharynx. A nasal snare is passed into the postnasal space, and by aid of the finger with the soft palate retracted forward the tumor is pushed into the loop of the snare. Drawing down firmly but not cutting it off, the snare is pulled on steadily until the growth gives way. Thus one will not only remove the growth within the postnasal space but the diseased membrane from the sinuses, in the form of a pedicle. Fig. 270, shows one of this variety of polypi properly eradicated.

The Eustachian orifices are usually involved in pathological processes from contiguous parts, as just described in tumors or much more frequently in disease of the tonsils and adenoids or inferior turbinates. These are in the form of obstruction either direct or by congestion, due to circulatory interference. As soon as these pathological processes are corrected the symptoms referable to the Eustachian tube openings will disappear. The most prominent symptoms are referable to the middle ear.

FIG. 270.—Sphenoid polyp, showing pedicle.

Mesopharynx. — In recent years there has been such a definite belief established in the fact that the tonsils which are situated within this space cause much trouble when they are diseased, and the thorough removal of them is so often followed by brilliant results that it behooves one to be well versed in the surgical anatomy of these parts, if he expccts to do good tonsillar surgery.

The tonsil surrounded by its fibrous capsule is wedged in between the two muscular folds known as the anterior and posterior pillars. Where these two pillars begin to diverge above they form a membrane known as the plica semilunaris which in most instances hides the upper portion of the tonsil. The remainder of this fold, called the plica triangularis, can always be seen near the base of the tongue, running from the anterior pillar back towards the posterior pillar. This plica is differently developed in different individuals and it is important to remember that after the tonsil has been removed; by compensatory hypertrophy, it often fills the space created by the tonsillectomy, and to the uninformed appears to be a part of the tonsil; in other words, an imperfect operation. Nothing could be more incorrect than to mistake it for a remnant of the tonsil. When depressing thebase of the tongue one will observe, in many cases, quite a mass of lymphoid tissue below the plica triangularis which runs right into another mass of lymphoid tonsil. Special attention is called to this lymphoid tissue, because after a very thorough tonsillectomy it not infrequently occurs that the lymphoid tissue undergoes marked compensatory hypertrophy and also looks as if some of the tonsil was not removed. Only that portion of the faucial tonsil is exposed to view which contains crypts and is covered by epithelium. The capsular part is entirely hidden. The capsule is very loosely attached to the deep layer of the deep fascia of the neck and after a clean tonsillectomy, especially by the Sluder method or many of its modifications, it will be seen as a perfect cavity with absolutely no injury to the fascia or any of its neighboring muscles. As a matter of fact in many cases one can observe small venous channels traversing this cavity without the least injury to these vessels. The blood supply to the tonsils is received principally from branches of the external carotid artery (Fig. 271) and is distributed as follows (Fig. 272).

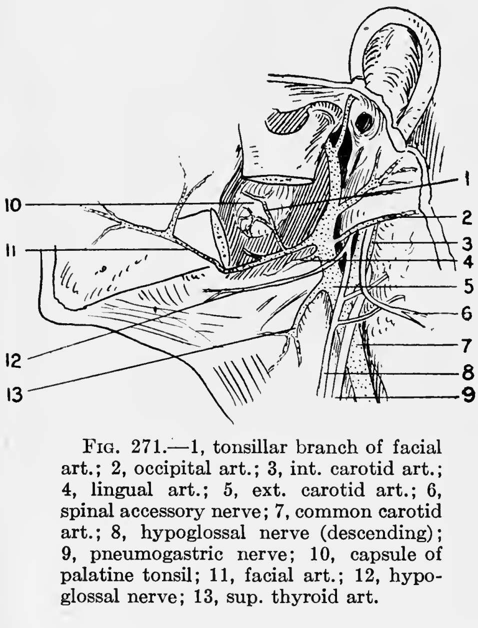


Fig. 271.—1, tonsillar branch of facial art.; 2, occipital art.; 3, int. carotid art.; 4, lingual art.; 5, ext. carotid art.; 6, spinal accessory nerve; 7, common carotid art.; 8, hypoglossal nerve (descending); 9, pneumogastric nerve; 10, capsule of palatine tonsil; 11, facial art.; 12, hypoglossal nerve; 13, sup. thyroid art.

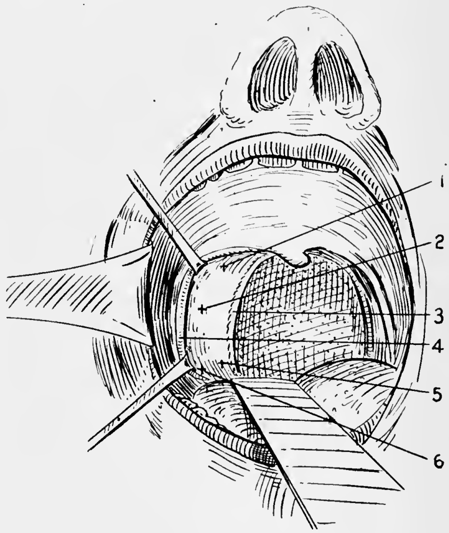


Fig. 272.—1, sphenopalatine branch; 2, tonsillar art. (facial); 3, post. pillar; 4, ant. pillar; 5, recurrent branch of lingual art.; 6, palatine branch of ascending pharyngeal art.

To the upper pole by the palatine branch of the sphenopalatine.

To the lower pole by the palatine branch of the ascending pharyngeal.

To its middle runs the tonsillar branch of the fascial, and anteriorly and low down is the twig from the lingual. In performing tonsillectomy these arteries are always severed so that there must of necessity always be bleeding; however, in the majority of the instances, these vessels are very small and retract very quickly and bleeding stops spontaneously. Especially is this true in children and young adults but in older individuals, where there is considerable chronic adhesive inflammation present about the tonsil and where the arteries are somewhat arteriosclerotic, ligation of some of them is frequently required, hence the thorough knowledge of their location is essential. It is necessary to retract the anterior pillars to expose to view the exact bleeding-points, especially those of the recurrent branch of the lingual.

The pathological conditions of faucial tonsils may be classified into two principle types:

A. Hyperplasia of the lymphoid tissue of the tonsil.

B. Infection of the crypts and retention with secondary infection and inflammation of the tonsil and peritonsillar structures.

The former change is usually found in infancy and should not be very much interfered with surgically. It appears to be a normal response on the part of the lymphoid ring within the pharynx to metabolic processes or for defense against infection.

The second form of tonsillar disease is where we find the greater variety of changes, both locally as well as distant from the tonsils. Such tonsils may be large or small, they may appear red, pus or caseous masses may or may not be expressed from them, they may feel hard or soft to the touch, there may be glandular enlargment within the neck and they may cause one or more systemic diseases, usually spoken of as a chronic septic (focal) infections.

Locally there will be most frequently met either a simple follicular infection or peritonsillar abscess. Associated with this infectious tonsillar disease in childhood and early adolescent life, pathological changes in the adenoid tissue of the epipharynx will also be found. This gives rise to an additional group of symptoms that are most important, in the life of the individual. Mouth breathing, repeated infections of the upper and lower respiratory tract including the middle ear, are some of the commonest complaints. The apparent malnutrition or delayed development both mental and physical are well known and believed today to be due to chronic foci of infection in the adenoid. In the determination of the presence of adenoids, it is not necessary to introduce the finger postnasally which is only an additional factor in spreading the infection. One will determine whether adenoids are present at the time of operation on the tonsil. The writer has held for a good many years, that a surgical tonsil is also a surgical adenoid, and *vice versa.* Of course that does not apply to the lymphoid hyperplasia in the infant in whom it is often necessary to remove part of the adenoids and a portion of the tonsil in order that the child may suck the nipple, or drink. It frequently occurs that associated with this lymphoid hyperplasia, there is repeated infection about the nose, ears or bronchi: and the question is, should such a child be subjected to a radical operation. The writer's practice has been to defer such radical attacks on the tonsils and adenoids until the child is three years of age. Why? There have been observed in a number of infants operated upon radically before the age of three, a condition not unlike myxedema which gives foundation for the belief that there is a close association between the functions of the thyroid, thymus and lymphoid tissue of the neck. It is unnecessary to recapitulate all the local and general manifestations or diseases that are accredited to infectious tonsils and adenoids; however, while there can be no doubt that in severe and chronic conditions everyone has seen most striking results follow a thorough tonsillectomy and adenectomy, yet there is no doubt that the operation has been too zealously overworked. The writer is referring to the promiscuous removal of tonsils as a method of excluding this possible source of infection, in a patient complaining of indefinite symptoms, before the physician has made a serious effort otherwise to arrive at a diagnosis. Another very unwise habit is that of minimizing of the possible dangers from a tonsil or adenoid operation.

Treatment.—In acute conditions, whether primary, engrafted or recurring, exacerbations should always be treated non-surgically unless it be an abscess and even that should not be attacked too soon in its development.

The principles in the treatment of acute tonsillar infection are rest to the parts and elimination of the toxemia resulting from the infected tonsils and adenoids.

The less the amount of mechanical treatment, such as sprays and swabs, the better; because these methods are only irritating and prolong the process. It is well known that gargles do not reach very much of the tonsillar area. However, a mild, warm gargle of normal saline or weak bicarbonate of soda solution has a tendency to relieve the pain and rid the oropharynx of thick secretions. To guard against complications in the middle ear, blood and kidney, is very important; and, though not apropos, it is well to call attention to the importance of a correct differential diagnosis between acute follicular tonsillitis and diphtheria.

In the management of a peritonsillar abscess, as stated before, one should wait until pus has actually formed, because the stabbing into and about the tonsil is both painful and retards recovery. If one should see the case in the very beginning he may prevent the abscess from developing by gently retracting the anterior pillar at the uppermost portion of the tonsil to permit the escape of the pent up infection. Under no circumstances should one employ probes or look for the seat of the infection. Once the abscess is formed then the use of hot water in the mouth, and holding it there until it has cooled is very gratifying. It is repeated every ten minutes for one hour and then the patient is allowed rest for one hour. This heat is beneficial both for relieving the pain and hastening suppuration. The place where one will detect fluctuation, usually about the third day, is above the supratonsillar fossa. In rare instances the pus formation is in the posterior pillar. The uvula is always more or less edematous especially when the abscess is located in the posterior pillar. To open the abscess one will at times have considerable difficulty in inducing the patient to open the mouth wide enough to get at its site. It is very painful especially if one attempts to open the mouth too suddenly. Five or ten minutes should be consumed in that procedure. Then apply pure flake cocaine over the fluctuating area, to be incised. By means of a curved hypodermic needle; the mucous membrane is next injected with $\frac{1}{2}$ to 1 per cent. procaine or apothesin. Without the least pain an ample incision then can be made until the pus is reached. With the aid of a blunt pointed artery forceps, the opening is further enlarged and the pus evacuated. Very seldom does the abscess recur at the same place, but practically always the patient will give a history of a repetition of these abscesses, usually in the beginning of the winter.

Whether the process is recurrent acute follicular tonsillitis or peritonsillar abscess, the indications are quite clear for removal of the tonsils, but one should not do so, until all the acute symptoms have disappeared. This usually requires from ten days to three weeks. It is true that the removal is very much easier, the sooner one operates after an acute attack, but the possibility of a septic process in the throat, mouth or neck which has been reported in several instances, should keep one from operating too early.

The treatment of chronic tonsillar disease whether causing or supposed to cause local, regional or systemic conditions, requires only one kind of treatment, and that is a thorough operation, known as tonsillectomy; and if adenoids are present then the same type of treatment should be simultaneously addressed to that structure. What is meant by a thorough tonsillectomy? It means the removal of the entire tonsil with its capsule intact, without appreciable destruction or injury of neighboring parts. It further means the safeguarding of the patient against any complications such as accidents from anesthesia, hemorrhage, sepsis and chemical changes in the blood as, for instance, acidosis.

As to the technic employed it does not make much difference. As will be shown, there are two important methods in vogue at present, both of which have their advantages and disadvantages.

The two methods are:

1. Dissection.

2. Removal by one instrument without preliminary dissection, known as the Sluder Method or one of its many modifications.

Safeguarding against possible complications is of utmost importance.

I. **Accidents from Anesthetics.**—The operation may be performed under local or general anesthesia. In children and many nervous and apprehensive adults, it is better to operate under general anesthesia. The great advantage in saving time and the disagreeable after-effects from general anesthesia, make the operation under local, topical and infiltration anesthesia, a great favorite. However, several of the technical points, for instance, ligating vessels, are made very much more difficult under local anesthesia. Ether is the anesthetic *par excellence* to be employed although nitrous oxide and oxygen furnish a valuable adjunct in the induction of sleep. The use of morphin before operation either with or without atropin is also a very good plan, but not as a routine, because there are people who know that morphin does not agree with them and it should not be used in such cases. It is necessary to vaporize the ether in tonsil and adenoid operation, because the work is performed with open mouth and considerably more time is required for the anesthetic than is safely obtained by drop or cone method. This vapor anesthesia is much more difficult in application and a patient will very frequently go into a deep narcosis with dilatation of the pupils, if not carefully watched. In order to facilitate the removal of secretion and blood during the operation, there should always be at hand some kind of apparatus, in the form of vacuum suction that will take care of them. This same suction process acts as a sort of pulmotor when too much ether has been inhaled. The writer is of the opinion that this suction apparatus is in a measure responsible for the non-occurrence of pneumonias or lung abscesses as a complication to tonsillectomies under general anesthesia.

The control of the bleeding is best done by ligation. It is perhaps difficult for some to ligate deep down in the pharynx, but if one will make it a practice, it will soon be as simple as other ligations. Silk is the material employed although there is no objection to catgut and it has the advantage that it does not have to be removed, whereas silk ligature must be removed at times, although in most instances it drops off. To facilitate ligation the writer places the ligature around an artery forceps by the aid of a needle, tying to either side of the forceps. Great care should be exercised in picking up the bleeding points not to penetrate the fascia with the forceps. The writer picks up these vessels with an Ellis' pickup forceps.

General sepsis is absolutely excluded in tonsillectomies and the writer can only refer to the complication from hearsay or literature, not having encountered a single case. This is accounted for by the fact that a tonsillectomy is considered a major operation and the same preparation of patients, instruments, etc., is made as for a laparotomy. Local infection (saprophytic and posttraumatic) always occurs, but there is very little difficulty from this occurrence and it passes away within a week, with or without treatment. Iodin, locally, is one of the best measures for this condition.

Acidosis does not occur since each patient receives an instillation of 30 to 60 grains of bicarbonate of soda in solution per rectum before he is brought to the operating-room. Should such complication occur then an intravenous injection of bicarbonate of soda or glucose, of each 30 grains in solution, will quickly clear up the condition. It stands to reason that the lungs and kidneys are always carefully watched after operation, but the writer can report no complication from this source.

The difficulty with local anesthetics is that neither the mental attitude nor the muscular reflexes can be absolutely controlled. The effects of anesthetics also vary in different individuals. The writer has noted that the men who use a great deal of tobacco react or gag very much more than those who use it moderately or not at all. Formerly the alcoholic had to be considered in the same class. Certain races are more reactive and sensitive to pain than others. Russians and Italians are practically impossible to handle under local anesthesia. The local application of pure flaked cocaine to the entire nose and pharynx, including the base of the tongue, will go a long way toward anesthetizing and quieting the majority of the patients' throats, for tonsillectomy. The infiltration by procaine or apothesin is not carried out until just before the removal of the tonsil from the deep attachment, as will be shown in the technic.

Technic.—Tonsil and adenoid operations under general anesthesia.

Sluder's Operation.—1. A nitrous oxide anesthetsia is preferred.

2. After the patient is completely anesthetized (the gag having been placed in the mouth before the gas was started), the mouth is opened wide, the tongue depressed, the tonsil is lifted out of its fossa by means of the Sluder guillotine (Fig. 273) and drawn forward and over the molar eminence situated on the inner surface of the inferior maxillary bone corresponding to the second molar tooth.

3. Holding the tonsil firmly in this position and adding pressure, the tonsil will pass through the fenestra of the instrument.

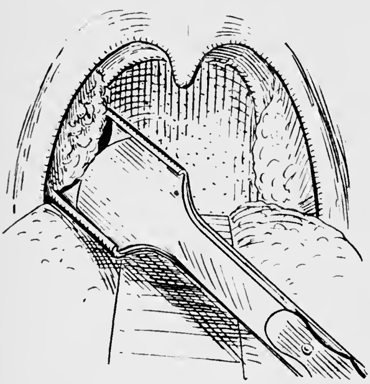


Fig. 273.

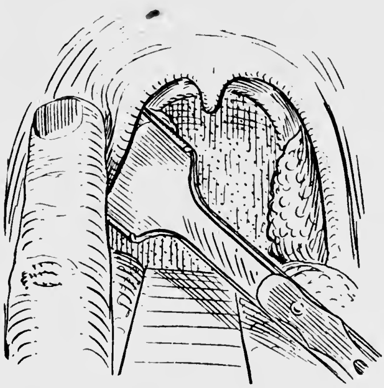


Fig. 274.

4. To aid this maneuver the thumb or finger of the opposite hand is used to work or massage the tonsil through the fenestra. At the same time the semi-sharp blade of the instrument is driven home slowly, until the entire tonsil protrudes on the mesial side of the instrument (Fig. 274).

5. By the aid of additional pressure from an arrangement on the handle, the attachments of the tonsil to the surrounding structures are severed and the tonsil removed with the instrument.

6. In many instances the second tonsil is removed by the same technic and with the same dose of gas, but usually the patient is re-anesthetized and then the second tonsil removed in the same manner.

7. The bleeding from the first tonsillar cavity is controlled by pressure sponges on holders. After the second tonsil is removed and the bleeding controlled by pressure, the adenoids are removed.

8. The patient is now practically awake although not struggling. However, if that should take place, then the patient is anesthetized for the third time. The removal of the adenoids is performed by lifting the patient from the flat position to a semi-sitting position for curettage

with an adenoid curette. The subsequent bleeding is permitted to cease by having the patient turned upon his face.

Modification of Sluder's Technic.—There are very many, but none differ from the original principle of lifting the tonsil from its bed by the instrument and pushing it through the fenestra of the same.

La Force Technic.—The principal change lies in the use of the La Force instrument (Fig. 275). It is an apparatus that holds down the dislodged tonsil by a dull blade, to produce pressure hemostasis while the tonsil is removed or severed from its attachment by a sharp blade. The object is to minimize the bleeding.

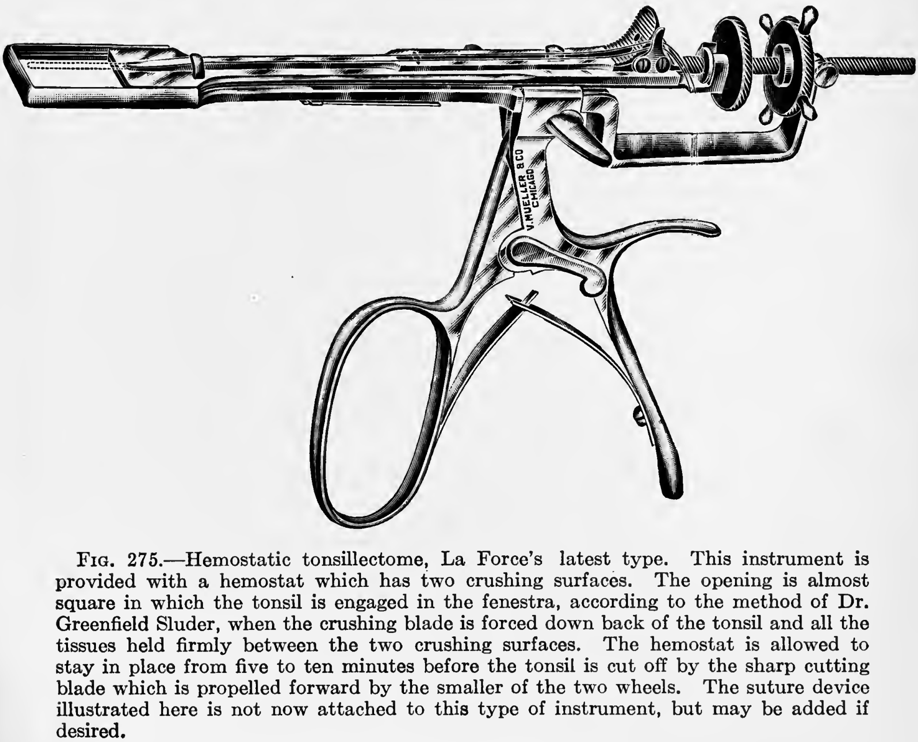


Fig. 275.—Hemostatic tonsillectome, La Force's latest type. This instrument is provided with a hemostat which has two crushing surfaces. The opening is almost square in which the tonsil is engaged in the fenestra, according to the method of Dr. Greenfield Sluder, when the crushing blade is forced down back of the tonsil and all the tissues held firmly between the two crushing surfaces. The hemostat is allowed to stay in place from five to ten minutes before the tonsil is cut off by the sharp cutting blade which is propelled forward by the smaller of the two wheels. The suture device illustrated here is not now attached to this type of instrument, but may be added if desired.

Beck's Technic of the Modification of Sluder's Operation.—The writer recognized very early in the history of the Sluder operation, its great value, adapted it and demonstrated it in the Cook County Hospital to many men, chiefly specialists. He also very early recognized, what to him were difficulties. In order to overcome them, he devised the following technic as fairly well outlined in the paragraphs on safeguards to patient.

1. Patient lies flat on the table, having put on a canvas restraining jacket (Figs. 276 to 278) to prevent him from struggling while being put asleep, yet not interfering with respiration.

2. Nitrous oxide and oxygen anesthesia is followed by drop method of ether from a cone, and by open method of ether vapor anesthesia from Beck-Mueller apparatus (Fig. 279).

3. Introduction of mouth gag.

4. Two small rubber urethral catheters passed through the nostrils and out of the mouth; loose ends held by a small clamp (Fig. 268).

5. Depress the tongue and by means of Beck's tonsillectome (Fig. 280) lift the tonsil from its bed into the supratonsillar fossa. Care should be exercised to get the lower pole of the tonsil well engaged into the ring of the instrument when dislodging the tonsil upward.

Fig. 276

Fig. 277

6. Without the least change in the position of the tonsillectome, the finger of the opposite hand feels the dislodged tonsil in the supratonsillar space, and begins to make firm pressure over the round eminence, while holding the tonsillectome equally firm. In the majority of cases, especially in children, the tonsil will be dislodged through the fenestra without great effort, but in some cases more persistent effort is necessary before all the adhesions give way and the capsule of the tonsil turns upon itself. Great caution must be exercised at the time of pushing the tonsil through the ring, not to use the fingernail, otherwise

trauma or even perforation of the anterior pillar may result. Also in holding the tonsillectome in its supratonsillar position it must never be permitted to slide about, but should be held in one position right against the dislodged tonsil.

7. The tonsil having been dislodged by the index finger one will feel the margins of the ring, while holding the finger to guard against the tonsil slipping back, the thumb of the same hand or the assistant releases the lock of the snare and the same is drawn down until considerable resistance is felt. Then the snare is locked again.

Fig. 278
Figs. 276, 277 and 278.—Beck-Hanson's restraining jacket.

8. One can now see the tonsil protruding mesially (Fig. 281), while at the anterior pillar is seen a retraction corresponding to the tonsillar capsule turned upon itself which indicates a successful enucleation.

9. Drive into the protruding tonsil the Lewis double screw (Fig. 282) to keep it from dropping into the throat when it is raised.

10. Turn the thumb ring of the tonsillectome from right to left,

which turns the screw shaft of the snare as the wire is cutting off the attachment of the tonsil to the surrounding structures.

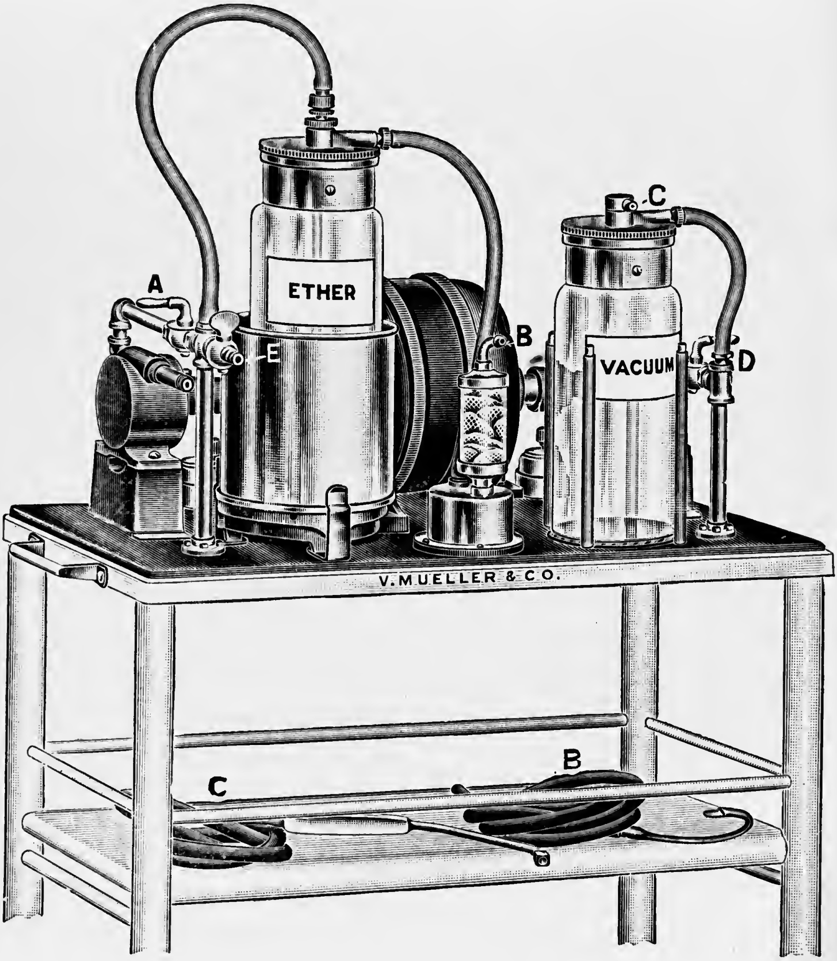


FIG. 279.—The Beck-Mueller ether-vapor and vacuum apparatus. This apparatus is the result of several years of experimentation, having been placed on the market only after its practicability had been thoroughly demonstrated. Ether-vapor, properly warmed, has been extensively used for some years; advantages of ether-vapor in preference to the drop method of anesthesia being generally conceded. The foot or hand pump, however, has made this a rather inconvenient method, requiring too much of the anesthetist's attention. Aspirating blood or mucus means a very considerable saving of time and gives the operator a clear field. The Beck-Mueller apparatus combines these two principles. The motor of special design by direct connection drives two pumps, one for pressure and one for vacuum. The air under pressure is sent to the ether bottle, where the ether-vapor is formed. Especially designed electrical heating units keep the ether from becoming too cold and also warm the ether-vapor just before it is sent to the patient. A filter absorbs any dust particles or other foreign materials, thus producing a suitable warm ether vapor continuously delivered at a low pressure. The vacuum pump creates a constant vacuum within the bottle.

11. The anesthetist grasps and pulls the rubber catheter on the side corresponding to the tonsil that was removed, and draws the soft

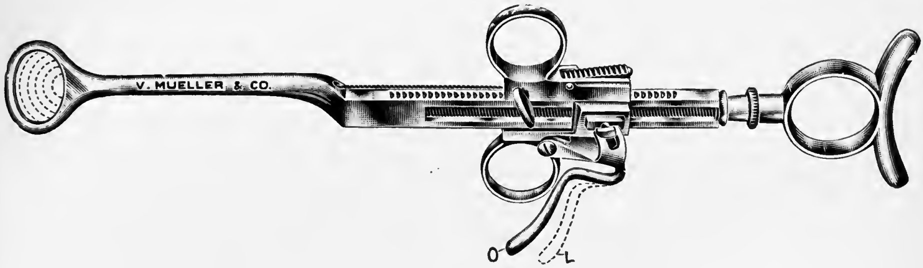


FIG. 280.—Beck's tonsil snare.

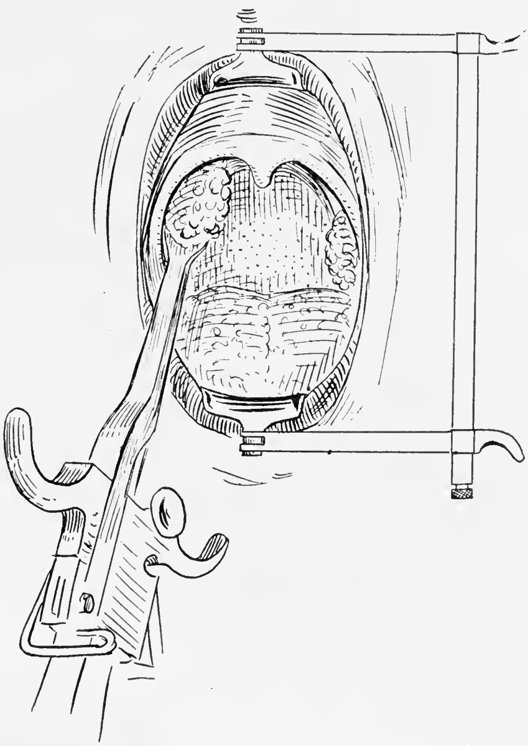


FIG. 281.

FIG. 282.—Lewis's double screw.

palate forward, thus bringing the anterior and posterior pillars in apposition and obliterating the tonsillar cavity, holding the bleeding for a time. Pressure of this traction also compresses the upper blood supply.

12. The escaped blood and secretions are sucked up and a small gauze sponge on an Ellis pickup forceps is put into the formed pocket of the anterior and posterior pillars, by the traction on the catheter.

13. The same technic is carried out on the opposite side, only changing from one hand to the other. The same management of the tonsillar cavity as in the first instance.

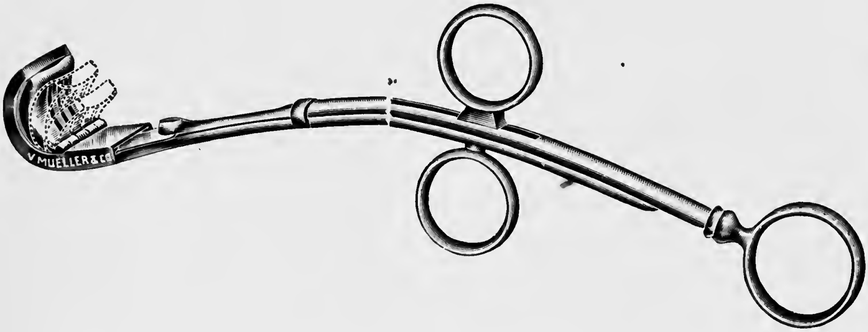


Fig. 283.—Stevenson's adenotome.

14. Both catheters are now drawn over the face of the patient, and if there is no very active bleeding from either tonsillar cavity, the adenoids are removed. This is accomplished by the aid of the Stevenson modification of La Force adenotome (Fig. 283). Only a part of the adenoid is removed with this instrument, the remains of the tissue being removed by the adenoid curette. While this slow and light pressure removal of the adenoids by the curette is going on the assistant has the suction tube in the oro- and hypopharynx to prevent any blood being aspirated.

15. Should there be any evidence of adenoids laterally in the region of the Eustachian orifice or on the posterior surface of the posterior pillars, then the dull ring curette (Fig. 284) is made use of.

Fig. 284.—Maier's dull ring curette.

16. Having completed the removal of the adenoids a strip of gauze, folded four times, and one-half inch wide and six to ten inches long, is packed into the postnasal space, the catheters relaxed so that the soft palate holds that strip in place. This entirely controls the bleeding.

17. The tonsillar fossæ are now inspected for bleeding and if there be any, each bleeding point is picked up and ligated. As mentioned in the paragraph on safeguard of patient, retraction of anterior pillars is often necessary to find the bleeding point. This is best done by

retractors (Fig. 285). The most troublesome bleeding usually occurs low down in the tonsillar fossa.

18. When all bleeding in the tonsillar fossæ is controlled the catheters are once more drawn forward, the folded gauze strip removed and the postnasal space inspected. Should oozing start anew, with one or two curved artery forceps the surgeon can grasp the median region of the posterior vault which invariably controls the bleeding after a few moments.

19. The patient is returned to his room with the face turned down, lying on his stomach with a pillow under his chest so as to make the throat much lower than his chest.

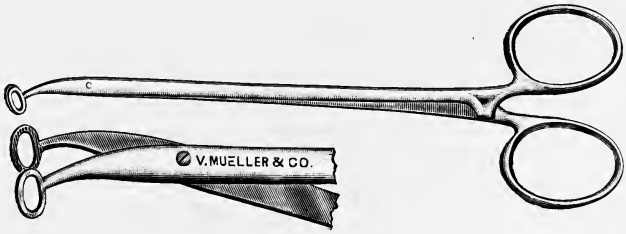


Fig. 285.—Beck's tonsil pillar retractor.

Dissection Method.—Until Sluder presented his method of tonsillar removal, the dissection method was considered the only ideal operation, for the removal of tonsils. It was with considerable reluctance that the majority of operators even gave consideration to the technic introduced by Sluder. Had it not been the for fact that Sluder was a recognized authority on rhinolaryngological subjects, the writer is convinced it would have taken much longer before such a departure from the well-established dissection operation would have been adopted. Even today there are many operators dissecting tonsils and it is a good thing that every one knows the dissection operation, especially the young or less experienced. The reason for this is that should one fail with the single instrument operation, he has always recourse to the dissection method.

Technic.—1. Up to the point of employing the single instrument (guillotine or snare), whether under local or general anesthesia, the technic is the same.

2. Drive the Lewis double screw (Fig. 282) into the substance of the tonsil near its upper pole and draw it toward the median line and somewhat downward. This brings the anterior pillar on the stretch at the attachment of the tonsil.

3. Allowing a thin collar of the margin of the mucous membrane of the anterior pillar attached to the tonsil, a semicurvilinear incision is made down to the capsule by means of knife (Fig. 286). Great care should be taken there, not to penetrate the capsule (Fig. 287).

4. By the aid of the long-handled, curved Mayo scissors the incision is enlarged both downward to the anterior pillar and over the supratonsillar region to the posterior pillar.

5. Pulling more firmly on the double screw tenaculum the head of the tonsil is dislodged and the remaining loose attachment brought on a stretch (Fig. 288).

6. With the same scissors these attachments of the tonsils are severed especially low down anteriorly at the plica triangularis and posteriorily from the posterior pillar.

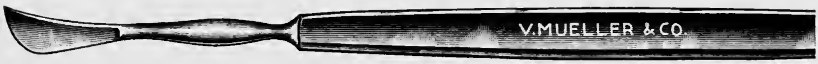


FIG. 286.—Beck's knife.

7. Removing the double screw tenaculum from the upper dissected pole and driving it into the lower half for the purpose of better engagement into the snare or for complete dissection without the snare.

8. Passing the tonsillectome (Fig. 280) over the tenaculum and drawing the dissected portion of the tonsil through the ring the lowest portion of the tonsil is further lifted into the ring, the wire released and drawn down.

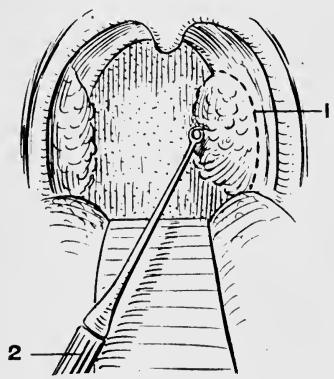


FIG. 287.—1, incision; 2, Lewis's screw.

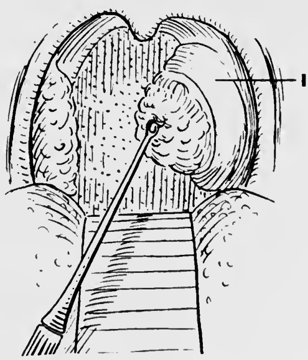


FIG. 288.—1, capsule.

9. Inject by means of a hypodermic about fifteen minims of $\frac{1}{2}$ to 1 per cent. procaine or apothesin solution into and external to the mass held by the snare.

10. Turn the thumb ring from right to left until the remains of the tonsillar attachment is severed.

11. Instead of employing the snare, one may complete the removal of the lowest portion of the tonsil by means of the scissors. This is less painful and more certain to get this mass of hypertrophic lymphoid tissue mentioned in the surgical anatomy, which so often undergoes compensatory hypertrophy and makes it appear as though the operation had not been properly done.

12. The management of the bleeding, etc., is the same as when the single instrument is employed.

13. Should the bleeding persist as a general oozing or start up secondarily, then the introduction of a piece of gauze saturated in tincture of benzoin is placed between the anterior and posterior walls and sutured there for twelve hours (Fig. 289).

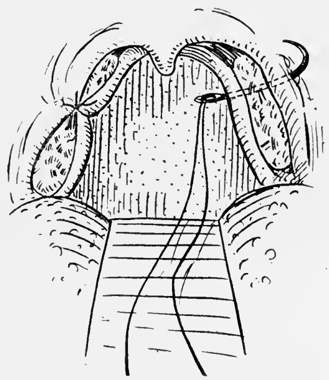


Fig. 289.

14. If in spite of these efforts the bleeding still continues then one must resort to the tonsil clamp (Fig. 290) which invariably controls the bleeding, but its retention is quite painful. Great care must be exercised not to use too much and too long a pressure, otherwise one may have a complication of necrosis or sloughing.

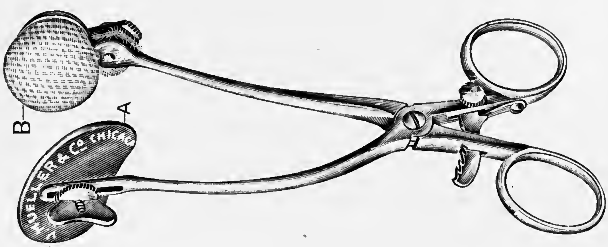


Fig. 290.—Beck's tonsil clamp.

In conclusion I wish to acknowledge the liberal way in which I have used the illustrations from Loeb's *Text-book on Operative Surgery of the Nose, Throat and Ear,* which were modified by Mr. A. B. Streedain.

SURGERY OF THE MOUTH AND FACE.

By GEORGE VAN INGEN BROWN, D.D.S., M.D., F.A.C.S.

DENTO-ALVEOLAR ABSCESS.

Dento-alveolar abscess is an accumulation of pus surrounding or associated with the apical end of the root of a devitalized tooth (Fig. 291).

Fig. 291.—Alveolar abscessed teeth showing granulomatous and other ill effects of dento-alveolar abscess upon the roots of teeth and the hopelessness of endeavoring to save roots of this character. (Latham.)

Pericemental abscesses occur in connection with the roots of teeth having vital pulps.

Etiology.—A tooth pulp may become devitalized through its exposure in the course of dental caries whereby it is subjected to irritation by the secretions of the mouth, bacterial invasion and other vicious influences. Severe traumatic injury may destroy the integrity of the bloodvessels and nerves as they enter the apical foramen and thus cause loss of vitality in tooth pulps. This may also occur from severe pericemental inflammation or infection in this region. Devitalized pulps usually become gangrenous. Sulphide of hydrogen and ammonia are thus formed in conjunction with ptomains and pyogenic microorganisms. Septic agents are then forced through the apical foramen by the confined gases within the pulp chamber of the tooth and thus infection of the alveolar structures surrounding the apex of the root results in due course in the formation of a typical abscess at that point. This may extend until the pus finds an exit through a fistulous opening into the mouth, or failing this becomes what is known as a blind abscess, or the pus may find its way through channels of bone until it reaches some more distant point of exit such as the maxillary sinus or the nasal cavity. It is the so-called blind abscesses that offer the greatest opportunity for the continuation of bacteria in these foci of infection for long periods of time without creating noticeable disturbance. Focal infection of this character has recently become a matter of much serious consideration in the treatment of disease. When the pulps of teeth are destroyed in the course of dental operations the complete extirpation of the pulp tissue from the root canal is required, and the pulp chamber must be completely filled to the apex of the root with some suitable material. This often is imperfectly done, and on account of innumerable small, tortuous, or otherwise defectively formed root canals, it is frequently impossible to accomplish the complete cleansing of such roots. Under such circumstances there is always likelihood of the occurrence of infection at the unfilled end of the root. In this way large numbers of dento-alveolar abscesses have occurred, the existence of which has not been suspected, and these are now understood to have been the cause of grave results as factors in creating pathologic disturbance (Figs. 292 to 295).

Bacteriological examinations of abscesses in connection with the roots of teeth by Rosenow,[1] Gilmer and Moody,[2] Hartzell and Henrici[3] show that in a varied flora the streptococci were found to be the most constant microörganisms.

The *streptococcus viridans* group is found almost universally present in alveolar abscesses and suppurative inflammations involving the pericemental and surrounding structures.

Pathology.—Rosenow describes the *pathological significance of dento-alveolar abscesses as foci of infection* in the following manner:

[1] Chicago, Illinois.

[2] A Study of the Bacteriology of Alveolar Abscess and Infected Canals, Jour. Am. Med. Assn., December 5, 1915, p. 2023.

[3] A Study of Streptococci from Pyorrhea Alveolaris and from Apical Abscesses, Jour. Am. Med. Assn., March 27, p. 1055.

"The affinity for joints, endocardium, pericardium, and often also myocardium and muscles, which characterizes streptococci when first isolated, tends to disappear on cultivation. It may be restored by animal passage and other strains of streptococci; under certain conditions it may be made to acquire the features of the strains from

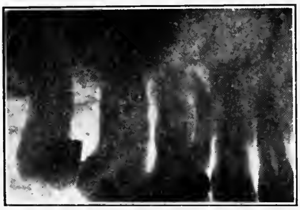


Fig. 292

Fig. 293

Fig. 292.—Dento-alveolar abscess associated with anemia.

Fig. 293.—Defective root fillings from the mouth of a business man with extensive interests, who broke down so completely that he was obliged to give up work and withdraw from active participation in the direction of the institutions with which he was connected. Travel abroad, trips to Carlsbad and other watering places, with consultation by prominent internists in this country and Europe gave no relief and no definite diagnosis. Urinalyses and blood examinations gave every evidence of diseased conditions, but no light as to the cause. Complete recovery followed the treatment and extraction of several diseased teeth.

rheumatism. When the rheumatic strains have acquired the cultural features of hemolytic streptococci they lose the affinity for endocardium and pericardium and acquire an even greater affinity for the joints. When they have been converted into pneumococci of a certain grade of virulence pulmonary hemorrhages and pneumonia are commonly

Fig. 294

Fig. 295

Fig. 294.—Large dento-alveolar abscess associated with a devitalized gangrenous pulp in the lateral incisor, the root of which was not filled, and imperfectly filled root canals in the first bicuspid and central incisor teeth. In this case the maxillary sinus was also involved.

Fig. 295.—Dento-alveolar abscess and bone destruction due to pyorrhea alveolaris. The maxillary sinus was involved in this case.

found after intravenous injections, whereas when the virulence is still greater, death from pneumococcemia results. These and other facts suggested strongly the possibility that previous to an attack of rheumatism various types of the streptococcus group, especially hemolytic streptococci, acquire in the tissues of the infected individual the features which give them the simultaneous affinity for joints, endocardium, pericardium and myocardium.

"The places in the human body where such conditions prevail and where special features are likely to be acquired are parts of infection such as in the tonsils, various sinuses, the appendix and about the gums and teeth. The importance of focal infections, as a point of entrance of bacteria in general is quite well recognized, but the idea that the focus serves in addition as a place where bacteria can acquire new properties is not generally recognized and needs to be emphasized.

"The strains from muscular rheumatism, especially after one or two animal passages, as well as other streptococci when they have attained a similar grade of virulence, show a marked affinity for the mucous membrane of the stomach, the pelvic mucous membrane and medullary portion of the kidney and the gall-bladder. Ulcer of the stomach, the picture of an ascending nephritis, cholecystitis with beginning formation of gall-stones, caused by streptococci, have been found repeatedly in rabbits and dogs injected with these strains, especially after one or more animal passages."

These conclusions have not been universally accepted. Howe and other writers do not believe they have been conclusively proved, nevertheless the work of Rosenow has been corroborated by some investigators and much evidence has been developed in the study of clinical cases that serves to emphasize the importance of these findings. It is therefore no longer a matter which occasions surprise when an important relationship is found to exist between foci of infection in connection with diseased teeth and cases of rheumatoid arthritis, iritis, endocarditis, myocarditis, ulcer of the stomach, disease of the kidneys, or anemia, leukemia and other affections manifesting themselves through blood disturbances; chorea, and many similar disorders of almost unlimited extent or pathological manifestations touching the brain, spinal cord and nerve structures in which infection may play a part.

Treatment.—Much confusion exists at the present time between dentists in their desire to save teeth, and physicians and surgeons, whose chief interest lies in relieving the affections from which their patients may be suffering without regard to the possible value of teeth that may be sacrificed. The extreme positions in this regard are represented by the dangerous practice of retaining diseased roots in the mouth which may continue to act as foci of infection with disastrous results, and the indiscriminate extraction of every tooth which may not be absolutely sound, in the more or less blind hope that some not fully understood disease may thus be relieved.

Rosenow and others incline to the belief that once a tooth pulp becomes devitalized such a root is always a menace regardless of the care with which the pulp may be extracted and the root canal filled. This opinion is based upon the fact that a tooth root contains not only the contents of its pulp canal including the bloodvessels, nerves, connective tissue, etc., but dentinal tubuli also. Since these tubuli

PLATE VI

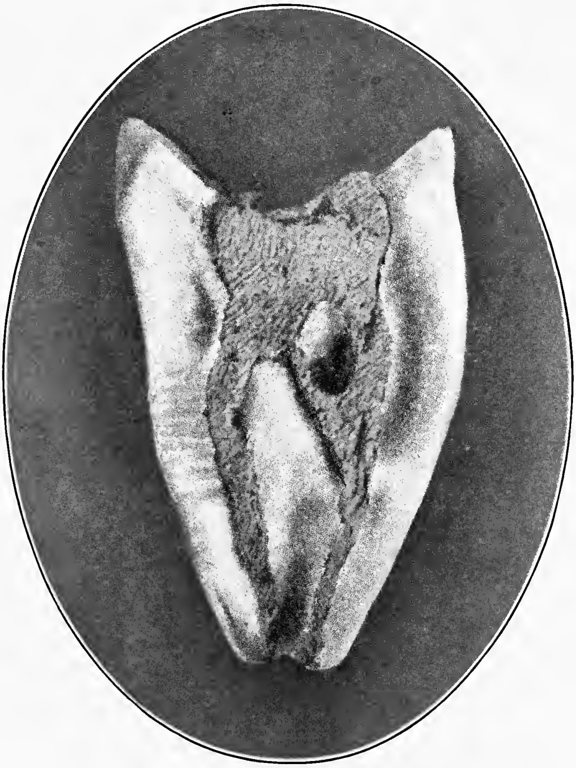
Fig. 1

Illustration of a Section of a Tooth with the Dental Tubuli Stained by Injection of the Tooth Pulp. A Rare Result Accomplished by Dr. V. A. Latham, of Chicago.

Fig. 2

Illustration of a Section of a Tooth with the Dentinal Tubuli Stained by Injection of the Dental Pulp. It also Shows the Result of a Pericemental Abscess. (Dr. V. A. Latham.)

PLATE VII



Dentin Impregnated with Rosin-chloropercha Solution.
(Callahan.)

extend throughout the dentinal structures of the root itself, their vital contents when deprived of the nourishment of a living tooth pulp may become disorganized and thus become foci of infection. (See Plate VI.) To meet this situation, Callahan of Cincinnati has added to the usual gutta percha point and gutta chlora percha (gutta percha dissolved in chloroform) root filling, a preparation of rosin which he has demonstrated can be made to permeate and seal these dental tubuli. (See Plate VII.)

This would seem to relieve doubt in that respect and should be insisted upon when medical practitioners are interested in the direction of the treatment of the roots of such teeth for their patients in important cases. The question of the possibility of the cure of dento-alveolar abscesses in such manner as to make it entirely safe to leave the affected root *in situ* when there is a suspicion of the pernicious influence of such foci of infection is a matter of much more difficult decision than the

Fig. 296

Fig. 297

Fig. 296.—Radiogram showing the result of a dento-alveolar abscess. In this case there was an acute arthritic affection of the left shoulder, severe long continued headache and progressive loss of vision. All these symptoms were relieved after surgical treatment of the diseased area, and proper filling of the root canals of the affected teeth.

Fig. 297.—Radiogram taken approximately one year after the one shown in Fig. 296 for the same patient. Bone regeneration in the diseased area is evident.

treatment of uninfected root canals. The surgical removal of such abscesses including the pyogenic membrane of the abscess sac and the surrounding alveolar bone structures may sometimes be successfully accomplished with complete relief of the affection apparently caused by such foci of infection and without loss of the teeth. Examples of this treatment are shown in Figs. 296 and 297). That this cannot always be accomplished with safety, is clearly shown by the illustrations of other cases in Figs. 292 to 295. Amputation of the apical portion of the root area that has been denuded of its pericementum and removing it with the diseased bone is occasionally successful in completely eradicating the diseased conditions when not more than one-third of the pericemental tissue has been lost.

For the guidance of physicians and surgeons the following rules of procedure would seem to be advisable.

1. It must be admitted that the value of a tooth or teeth cannot be allowed to weigh in the balance against the reasonable possibility of

relieving serious general affections. Extraction should therefore be insisted upon unless complete security in this respect can be given by the treatment of the roots of such teeth.

2. If an attempt be made to treat the root canals of suspicious teeth under these circumstances the sealing of the tubuli according to the Callahan, or some similar method should be insisted upon.

3. There should not only be radiograms to show the condition before treatment but immediately after also to prove that the root filling has reached the apical end of the root. If the root canal filling is imperfect it should be made perfect or the tooth extracted.

4. After a sufficient interval has elapsed another radiogram should be taken if necessary to demonstrate beyond the question of a doubt that there has been complete regeneration of the bone and pericemental structures surrounding the end of the root, with total obliteration of the abscess. With such care many teeth could undoubtedly be saved with safety. Without such precaution the only safe procedure is to extract the teeth in order to remove the risk of continuation of the disease.

5. It must not be forgotten that, in many instances, the indiscriminate extraction of teeth to relieve remote affections in the absence of complete diagnosis for the exclusion of other causes is a doubtful endeavor to relieve present ills with almost certain invitation of future disturbance. The extraction of even one tooth from a perfect dental arch, paves the way for malocclusion which may lead to pyorrhea alveolaris or some similar affection in the future. The loss of a number of teeth destroys the functional activity of the jaws and may make itself felt in the disarrangement of the digestive tract at some later period. Moreover the effect upon metabolism of proper or improper mastication of food is one that cannot lightly be overlooked.

With the foregoing rules for guidance, much may be done with safety for the simultaneous relief of focal infections and tooth preservation.

MOUTH EXAMINATION WITH REFERENCE TO FOCAL INFECTION.

Under artificial tooth crowns and bridges and above and below the roots of teeth that have been treated for long periods dento-alveolar abscesses, bone cysts or other sources of pus formation are matters of frequent occurrence. They may discharge through fistulæ and thus permit the microörganisms to meet the antagonistic agencies commonly contained in the buccal secretions, but quite often they find their way more or less directly into the bone circulation, and thus, without any neutralizing safeguard, perhaps with opportunity to gain increased virulence, as suggested by Rosenow, they assume a much more serious role than is usually appreciated.

These are the factors it is difficult to uncover, and they exist where least looked for.

The following suggestions, although by no means intended to be complete, will be useful for general practitioners of medicine and surgery to enable them in the course of more or less cursory examinations, such as would be practicable in an office examination, to at least determine the likelihood of the existence of pathogenic influences in the mouths of patients.

1. Note the general appearance of the teeth; the color and appearance of the mucous membrane of the mouth; and evidences of daily care, etc. Observe if the gums are inflamed; if there be discharge of pus about the necks of the teeth on pressure; if any of the teeth have been lost; and inquire if the patient has ever received treatment for pyorrhea alveolaris.

2. Make sure of the presence of the full number of teeth in the mouth according to the age of the individual, and endeavor to have missing teeth, if any, accounted for.

3. Examine carefully, with a small electric light in the mouth if possible or in strong sun light, the color of each tooth when compared with adjoining teeth. Vital teeth with living pulps are easily recognized by being more translucent than those in which the pulps have been destroyed. While teeth with living pulps may cause painful and other nervous affections they are not likely to affect the vitality of the individual. If the crown of the discolored tooth has no carious cavity and has not been filled, inquiry should be made for a history of previous traumatic injury. The faradic current gives positive distinction between teeth with living pulps and those in which the pulps have become devitalized.

Teeth that have large carious cavities or diseased roots which discharge through fistulæ upon the gum surface are easily discovered. Over and over again the author has found most serious and long-continued results from teeth that had no carious cavities and bore no outward evidence of being affected by any unusual condition except a more or less dark appearance when compared with adjoining teeth. Upon inquiry in these cases it has sometimes been found that there was a history of a fall some years before or a jar, which jammed the teeth tight together, or a traumatic injury of some sort, which, although it may have caused only temporary discomfort, yet was sufficient to injure the little nerve filaments that form the connection between the tooth pulp and the main nerve at the apical end of the root. The extension of disease from a pyorrhea pocket may also cause the same result without its being discovered. The pulp itself, having thus become devitalized, continues to supply a more or less constant infection which is forced up through the apical end of the root by the gases formed from gangrenous conditions within the pulp chamber, and is doubly dangerous because of the likelihood of direct absorption into the general system or distribution through the bone circulation.

4. If the teeth are irregular there will in all probability be a high narrow palate also. These defects are commonly associated with deflections of the nasal septum, contracted nares, spurs, and attendant chronic atrophic and hypertrophic internasal conditions, which in turn may be held responsible for diseased nasal secretions, the invari-

able results of which are pathological affections of the nasal accessory sinuses and the long train of local as well as general symptoms which may be expected in such cases. Such individuals are also frequently subject to mastoiditis and middle-ear disease

5. The abraded edges of the teeth will often show tendency to nervous disturbances indicated by tooth grinding in connection with which headaches, affections of the eye, neurasthenia, and similar affections frequently occur.

6. There should be a careful examination of the tongue to disclose evidences of chronic ulceration, the character of its surface, whether clean or thickly coated or deeply fissured or affected by leukoplakia. Protrusion of the tongue should also be insisted upon to show by its extent or deflection to one side or the other, the presence or absence of nervous conditions which might affect its proper control. Carefully taken röntgenograms must be the chief diagnostic aids in determining the presence or absence of foci of infection in this region.

PYORRHEA ALVEOLARIS.

Pyorrhea alveolaris (*Rigg's Disease, Chronic Alveolitis, Calcic Pericementitis, Phagedenic Pericementitis*) and other terms have been variously used to describe a chronic disease which affects the gum borders, the pericementum of the roots of the teeth and their surrounding alveolar structures, and which Talbot has included in the more technically correct term *Interstitial gingivitis.*

Surgical Aspect.—This affection has long been known to be intimately associated with many serious general affections as an etiologic factor of importance and as an indicative symptom. Recent developments in the study of focal infections have emphasized the frequency of its occurrence and the serious character of its influence as a source of infection of far-reaching pathological importance. It is therefore a subject of vital surgical interest.

A number of authors agree that, roughly estimated, 95 per cent. of all persons are more or less affected by this condition. Whether the actual percentage be more or less than this, the fact remains that chronic inflammations of the gingival borders and pericementum are very generally prevalent, and their tendency is to extend until the surrounding alveolar structures are also involved. For these reasons this source of focal infection cannot properly be ignored in giving consideration to the treatment of disease whether it be local or general in character.

Etiology.—It is known that continued local irritation at the gingival borders of the teeth, as from calcic deposits about the necks of the teeth or the disturbing influences of malocclusion and crowded dental arches, or imperfection in the form of the approximal surfaces of teeth from any cause that may favor conditions which lead to the accumulation of food particles and débris in their interproximal spaces, ill-fitting crowns and bridgework, and similar causes of local irritation may be active, predisposing and exciting factors. In scurvy, as well as conditions due to the excessive administration of mercurial preparations or lead and other mineral poisons, this form of destruction of the pericemental and alveolar tissues also occurs.

The presence of *parasitic amebæ* in pyorrhea alveolaris and other possible forms in the causation of this disease were brought to light through the efforts of Dr. Allen J. Smith, Professor of Pathology in the School of Medicine, University of Pennsylvania, and M. T. Barrett, D.D.S., associate instructor in Normal Histology, Dental Department of the University of Pennsylvania, whose preliminary report was published in the August, 1914, number of the *Dental Cosmos*. In the same report these authors describe their use of emetin as an amebicide with good results in the treatment of pyorrhea pockets. Their belief in the efficacy of emetin was largely based upon the findings of Col. Leonard Rogers of the Indian Medical Service in Calcutta, who in 1912 demonstrated this to be a useful as well as specific remedy against the endameba of dysentery.

The author is indebted to Dr. Allen J. Smith for the statement that he and Dr. Barrett have formed the following conclusions: "There are two forms of these parasites which may be found in and about the mouth, viz: *endameba gingivalis* (Gros in 1849 appears to have been the first to publish and discover the amebic parasites in the soft material on and about the teeth) and endameba pyogenes.[1] Apparently either of these two amebæ may be met in pyorrhea pus, but the first is the only one Dr. Barrett and I have found therein." "We do not believe that these are alone responsible for pyorrhea suppurations, and do believe pyorrhea may occur without their presence, but we do believe they are present in the great majority of such lesions, which we speak of therefore as amebic pyorrhea. We think their importance comes especially from a symbiosis with the vegetable microörganisms therein found, and we believe we break one link of that symbiotic chain when we use emetin, which is an efficient amebicide but (as far as known) only a poor bactericide. The chain broken in this wise, the suppuration stops. But the same result might be obtained by cleaning out both the amebæ and the bacteria by proper mechanical and antiseptic work, or it might be obtained by efficient bactericides as the exactly suitable vaccine for the individual case. To attack the amebic end of this symbiotic chain by emetin is the easy method, and seems to be proving commonly the most efficient method; but we would be improperly quoted if we were held to regard it as the only method."

Pathology.—Beginning with a slight gingivitis a chronic inflammatory condition is established at the gum border, which extends to the pericementum of the root, causing slight, though often imperceptible, elongation of the affected tooth. (The term *pyorrhea dentalis* suggested for the disease at this stage is likely to be misleading because of the practical impossibility of drawing such a line of distinction without microscopic confirmation.) A discharge of pus becomes established

[1] Verdum and Bruyant: L'Écho Méd. du Nord., 1907, xi, 375.

and absorption of the alveolar border with corresponding destruction of the pericemental and periosteal tissues results in the formation of distinct pockets upon one or more aspects of the affected roots.

Microscopic sections of these cases show that the surrounding bone is also more or less extensively involved. Lacunar and Haversian canal absorption as well as Halisterisis have been demonstrated by Talbot to be extended far beyond the area immediately surrounding the pocket. As the disease advances the necks of the teeth become exposed, the teeth loosened and ultimately lost. Devitalization of the dental pulp due to destruction of the nerves and vessels at the apex of the root sometimes adds seriously to the activity of pus formation.

Symptoms.—The most noticeable symptoms of this affection are discharge of pus from pockets about the necks and roots of the affected teeth. These also become elongated and loosened and finally drop out if the disease be unchecked.

Diagnosis.—The recognition of pyorrhea alveolaris when fully established is a simple matter. Pressure upon the gums about the necks of the teeth discloses the presence of pus; the loose teeth and receding gums are at once noticeable. The incipient stages, however, are not so easily recognized. It sometimes takes careful observation to note the slight local redness which may be the indication of an early stage at which slight corrective intervention would be sufficient.

Prognosis.—Inasmuch as there is no evidence that the pericementum when once destroyed and a root surface thus exposed is ever regenerated, and since there can be no direct union between gum tissue or any fibrous substitute and such a root surface, it follows that no matter how tightly the gums may contract as in many reported cures, such areas must continue to favor the recurrence of infection. This tendency can only be overcome by absorption or shrinking down of overlying gum tissue of the pocket in the course of contraction. This result may follow destructive processes or be accomplished by surgical removal of free gum tissue to obliterate pockets down to the denuded bone at the pericemental border of the lesion. The prediction as to the permanency of beneficial results that may have been accomplished in treatment by any method or remedy must necessarily be governed by the completeness with which this difficulty may be overcome and the efficiency with which other predisposing factors may have been controlled. It is of the greatest importance that the patient be given minute directions to cleanse the teeth before and after eating after this condition has been cured in order to prevent reinfection which is favored by the condition of the gums after recovery from this condition.

Treatment.—Treatment, so far as the surgeon is concerned, consists in recommending the extraction of hopelessly loose teeth which cannot be restored to usefulness and which must continue to be a menace. The thorough cleansing of the teeth is necessary, and the correction of any existing malocclusion of the teeth. Attention should also be given to the regulation of intestinal conditions. This treatment may be supplemented by the administration of emetin, but the emetin treatment so often proves ineffective, that tincture of iodin as recommended by Talbot is a much more reliable remedy. This should be applied to the gums with an applicator of cotton wound on wooden toothpicks. Further treatment of this condition should be carried out by a competent dentist.

Talbot's Iodoglycerole

℞—Zinc. iodid.	15 parts
Distilled water	10 "
Iodin crystals	25 "
Glycerin	50 "

Sig.—Apply to gum with an applicator.

In explanation, it is important to note that by artificial means, through local irritation, the discharge of pus from the alveoli, the formation of pockets about the roots, with ultimate loosening and loss of the teeth involved, can be induced notwithstanding every kind of therapeutic treatment that might be applied. The continual administration of mercury, and scurvy caused by the elimination of all vegetable foods from the diet can also cause disease of the gums, the pericementum and the alveolar structures with similar results no matter what degree of careful local cleanliness may be observed.

The continued movement of a tooth in its socket will cause bone absorption with corresponding loosening and a reduction of local resistance which will render its surrounding structures extremely susceptible to all infectious influences. Bearing in mind these facts, it becomes evident that the ideal treatment for pyorrhea alveolaris must be one that includes the careful elimination of every form of local irritation in so far as may be possible; the fixation of loosened teeth; the careful correction of adverse intestinal conditions by dietetic regulation.

Ionic Medication.—Dr. Percy B. Wright, of Milwaukee, reports good results from ionic medication according to the method advocated by Ernest Sturridge,[1] who states that treatment consists in thorough instrumentation, removing every particle of foreign substance and polishing the necks of the teeth. Ionic medication indicated consists in passing zinc ions into the gingival trough. A zinc electrode, spear shaped, of large enough size to readily enter the trough should be wound at the point with a little cotton-wool, saturated with 3 per cent. zinc chloride solution and passed into the space; the current from the positive pole should then be turned on gradually, the patient holding the negative electrode. The teeth should be kept free from moisture from the mouth, the electrode should be very slowly moved around the necks of the teeth, which, if not sensitive, will tolerate 2 or 3 ma. current. The trough is in this manner sterilized with zinc ions which migrate readily even with very much less current strength. The time required to go round each tooth should occupy on an average about a minute, some places requiring a longer time, others less affected, a

[1] Dental Electrotherapeutics, Lea & Febiger, 1918.

shorter. Discretion must be used in the matter of time required to sterilize soft tissues. Ions are conductors of current and move instantaneously, the time and current strength work in direct ratio to each other to produce depth of penetration. In mucous tissue (2 ma. current with a small area electrode) the current density is very great, and the dose of ions provided in one minute over a small area of a gingival border must be considerable.

One treatment will often be sufficient if all foreign matter has been completely removed, and the teeth polished, but the patient should be seen in three or four days, and if this condition has not been fulfilled, redness and congestion will be present wherever any irritant is lurking. This should be removed, and the affected part treated as before.

According to Smith and Barrett the directions for the use of emetin are as follows:

"The solution is introduced in the pyorrhea pockets with an ordinary hypodermic syringe with a straight or curved needle as needed, so as to gain access to all parts of the pockets. The point of the needle should pass along the root of the tooth to the bottom of the pocket, merely engaging with the wall, and be carried about to all of its parts. In one sense, of course, it would be well to actually penetrate the wall of the pocket, and thus in the discharge of the solution insure diffusion of the emetin in the surrounding tissues. However, this is not essential, and the mechanical harm done to the wall by the instrumental puncture, and that occasioned by carrying infective material through the wall by the penetrating point, are sufficient reasons for trying to avoid such strenuous and unnecessary efforts. Unquestionably bothersome local inflammation can be occasioned by failure to avoid this source of irritation. Each pocket in turn is thus filled with the emetin hydrochlorid solution. Treatments which thus include all recognizable pockets and special parts under suspicion should be repeated daily for at least five days, and thereafter every other day until about ten treatments as a total have been made, as a general rule. In some of the less marked and less chronic cases, a total of five or six applications or even less may be sufficient, while in the more stubborn instances treatment must be continued even longer than above indicated."[1]

Drs. Bass and Johns favor the hypodermic administration of ipecac and prescribe $\frac{1}{2}$ grain emetin hydrochlorid hypodermically each day for from three to six days, depending on the case and stage of the disease, but clinical results do not seem to warrant this practice.

Trench Mouth.—An infection with which pyorrhea alveolaris is easily confused and sometimes associated and which has been commonly known as trench mouth during the war is Vincent's disease or a fuso-spirochetal infection of the mouth. It may affect the tonsils from which a yellow sloughing ulcer often spreads to the soft palate and other parts of the mouth. A second form affects more particularly the gums

[1] Dental Cosmos, December, 1914, vol. lvi, No. 12.

and closely resembles pyorrhea alveolaris. Another type of the disease causes a general inflammation of the mouth and is not infrequently fatal in its results.

The microörganisms present are the fusiform bacilli, spirochete and a spirillum.

The diagnosis is by microscopic examination and differentiation must be made from diphtheria, syphilis, pyorrhea alveolaris and other forms of stomatitis.

Treatment.—The author's method of treatment in these cases, which are still quite prevalent among the returned soldiers, is to isolate the individual in so far as possible, particularly with reference to eating utensils, spoons, knives, forks, cups, etc.

The mouth is rinsed once each hour with dioxygen and listerine or some other suitable antiseptic mouth wash used alternatively. The gums are thoroughly swabbed twice daily with cotton applicators dipped in iodin. Salvarsan sprinkled upon the surface of the ulcers or salvarsan in glycerin swabbed over the affected surfaces appears to be particularly useful. Intravenous administration of salvarsan has been disappointing and is at least unnecessary except for syphilitics. As depleted conditions of the system whether from cigarette smoking or other causes render the system more susceptible to the Vincent's microörganisms, this feature requires attention by building up the bodily resistance. Usually the cases yield to treatment quite readily and when repeated cultures from the mouth show absence of the micro-organisms, the patient may safely be dismissed.

CYSTS OF THE MOUTH AND JAWS.

A cyst consists of a connective-tissue membrane or supporting wall lined by epithelium or endothelium, the contents of which may be fluid or semifluid, uniform in composition, or made up of a mixture of similar or dissimilar substances.

Cysts may be *simple* or *multiple.*

Classification.—(1) *Retention cysts* due to the occlusion of excretory ducts of glands. (2) *Exudation cysts,* caused by accumulations in cavities not supplied by excretory ducts. (3) *Cystoma,* a cyst that is the result of a new formation. (4) *Extravasation cysts,* those formed around distended or ruptured vessels. (5) *Dermoid cysts,* congenital cystic results of cutaneous inclusion. (6) *Parasitic cysts,* caused by animal organisms, as trichinæ and other parasites. (7) *Cysts resulting from necrotic and degenerative changes in solid tissues,* such as those formed in neoplasms from hemorrhage liquefaction, necrosis, and other forms of softening, as well as other degeneration processes.

Proliferous when the cyst walls continue to spring from each other or proliferate.

Multilocular when a number of cysts together remain distinct, and *cavernous,* when these communicate.

Retention Cysts of the Mucous Glands.—Retention cysts of the mucous glands are caused by occlusion of the ducts of these glands.

Symptoms.—These small pink or bluish cysts may appear on any part of the surface of the mucous membrane of the mouth. Occasionally they increase in size until large enough to interfere with the movements of the tongue or the occlusion of the teeth.

Treatment.—Extirpation with care not to rupture the cyst wall, thereby removing the cyst and its contents intact, is the best method of treatment. The mucous membrane edges of the wound surfaces are then sutured with gut. Treatment by cauterization and curettement are usually less effective and much more troublesome, because any position of the lining which has not been destroyed will surely cause a recurrence.

Deep-seated Cysts of the Mucous Membrane.—Deep-seated cysts of the mucous membrane sometimes have their origin under the foramen cecum and the third tonsil.

Symptoms.—In these cases contact with the epiglottis sometimes causes irritation and the resulting cough may be mistaken for an indication of some other affection. It is also frequently difficult to distinguish enlargement due to cysts of this character from hypertrophy of the lingual tonsil.

Diagnosis.—Their diagnosis depends chiefly upon examination with the aid of a laryngeal mirror.

Treatment.—Complete surgical removal or destruction by cauterization is required.

Cysts of the Glands of Blandin-Nuhn.—Cysts of the glands of Blandin-Nuhn appear in rare cases on the tip of the tongue. They are covered with pale red mucosa, are transparent, and occasionally become quite large.

Treatment.—Extirpations as for other mucous cysts.

Ranula.—Although this term has been somewhat loosely applied to retention cysts in the floor of the mouth, it should be used to describe more particularly cysts of the sublingual and submaxillary glands.

Etiology.—Occlusion of the ducts of these glands causes salivary retention. Sometimes this occurs from a congenital defect of the ducts, but usually as a result of some inflammatory process.

Symptoms.—Swelling under the tongue causes it to be displaced upward. Usually this appearance is confined to one side, but through great enlargement the cyst may extend completely across the mouth.

A ranula is commonly filled with a light-colored viscid fluid. Sometimes this has a brownish color and occasionally it is tinged with red or green. Such cysts may grow slowly or they may occasionally develop rapidly in the course of a few hours.

Diagnosis.—The situation differentiates ranula from mucous cysts; its consistency and mobility from other more solid growths. Comparative rapidity of increase in size distinguishes it from dermoid cysts which sometimes occur beneath a submaxillary gland and cause upward displacement of the floor of the mouth and tongue.

Treatment.—Opening a ranula causes it to collapse immediately but it fills up again almost as promptly. Removal of the gland or dissecting out the cyst wall may be effective, but is usually unnecessarily troublesome as is also the attempt to destroy the cyst by cauterization or curettement or packing with powerful acids. The reëstablishment of ducts to allow continuous escape of saliva is a simple and very effective method of treatment. This is easily accomplished, as shown in Fig. 298, by passing a wire loop completely through the cyst, securing the ends of the wire by a compressed lead shot and bending it in such a form as to enable it to rest under the tongue without

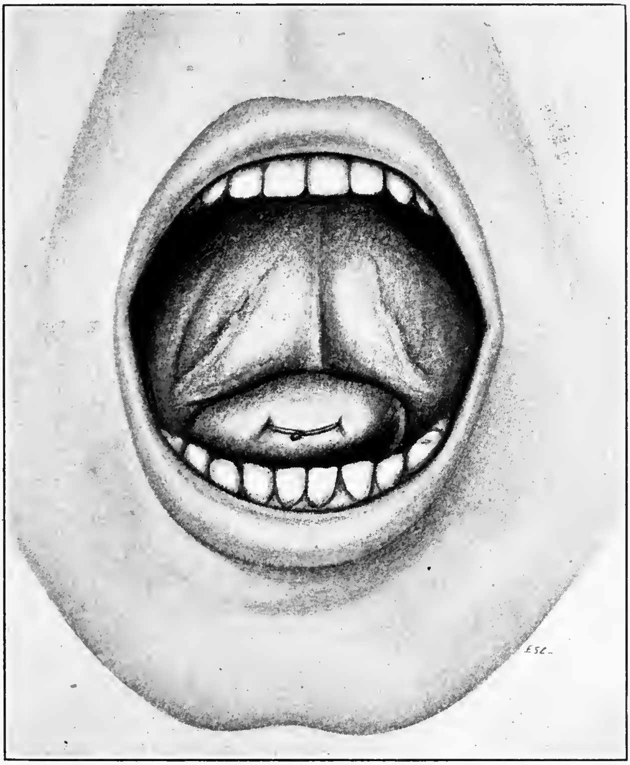


Fig. 298.—Illustration of a ranula with wire loop in place as treated in the case of a young girl ten years of age. Although operated upon several times before, the ranula never appeared again after insertion of the wire loop.

irritation or annoyance. The natural activity of the tongue causes sufficient movement of the wire back and forth to prevent complete closure of the opening. It may be allowed to remain in place for several weeks or months, if necessary, to ensure the permanence of the openings after the wire is removed. The importance of emphasizing the value of this simple procedure has recently been brought home to the author through some cases in which great anxiety had been occasioned by the frequent recurrence of the cyst after treatment, and much unnecessary suffering endured by the patient through ineffectual attempts to extirpate and also to destroy the cyst wall with powerful acids. It is only a momentary matter to pass a needle through the ranula with no appreciable pain. The wire when properly placed gives no annoyance, and the gland resumes its natural function without delay.

Hydrops of the Sublingual Bursa.—Skillern quotes Fleischmann and Lennon as being convinced that ranula arises through disease of the sublingual mucous bursa alone, the salivary duct only at times being involved in the same fashion. He quotes Tillaux[1] as being of the same opinion and gives Fleischmann's description of this bursa as illustrated in Figs. 299 and 300. He describes a case apparently like

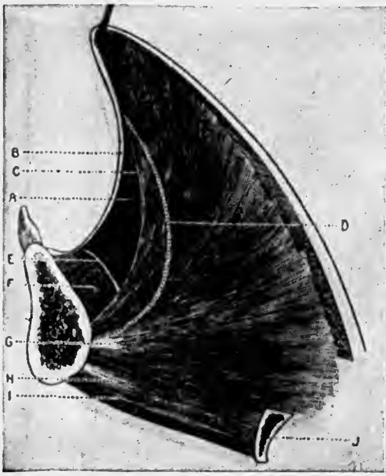


FIG. 299.—Sublingual mucous bursa, called Fleischmann's, seen upon an antero-posterior section of the floor of the mouth. *A*, cavity of the sublingual mucous bursa; *B*, its anterior or mucous wall; *C*, its posterior or muscular wall; *D*, the dotted line indicating the depth of the bursa; *E*, the duct of Wharton; *F*, the sublingual gland; *G*, the genioglossus muscle.

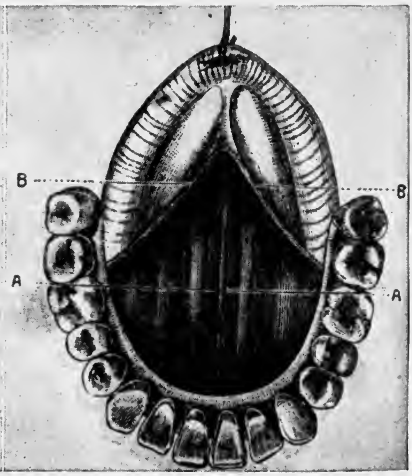


FIG. 300.—Sublingual mucous bursa seen from the front after one has previously raised the anterior or mucous wall. *A,A*, interspace between the two genioglossus muscles; *B,B*, borders of the mucous bursa.

ranula which continued after removal of the sublingual and maxillary glands and which he found was situated in the sublingual mucous bursa.

"A T-shaped submandibular incision was made over the swelling; on reflecting the skin and superficial fascia there was exposed a lax cyst with a thin, bluish-white wall. On opening the cyst there escaped a clear, glairy fluid. The orifice of communication through the mylohyoid muscle, corresponding to the constriction of an hour-glass, was tightly closed by a catgut suture, thus dividing the cyst wall into two cavities: an upper oral, and a lower cervical. The lower cervical was

[1] Anatomie topographique, p. 326; Lectures on Surgical Pathology, 1854, p. 335; Schmidt's Jahrb., 1841, xxxii, 88.

stuffed with gauze, aiming at adherence of its walls by obliterating granulation tissue. The upper oral cavity was marsupialized into the mouth cavity and likewise stuffed with gauze, with the same end in view."

Periosteal Cysts of the Jaws.—These cystic cavities occur in connection with the roots of teeth, or in sites that have formerly been affected by dento-alveolar abscesses even though the primary cause may have been removed. Their distinguishing feature is the lining membrane. Turner believes this to be an epithelial lining probably developing from a peridental epithelial remnant.

Symptoms.—The fluid contents of these cysts may represent any of the characteristic results of tissue liquefaction. They are usually painless and develop slowly. The external thin bony wall is sometimes forced outward, and thus its bulging facilitates diagnosis, but röntgenograms give the most prompt and satisfactory diagnostic indications of their presence, size and character.

Fig. 301.—Radiograph of a cyst of the lower jaw.

Treatment.—Treatment consists of complete removal of the cause, destruction of the cyst wall, and also of surrounding bone that may be affected. Packing the resulting bone cavity with gauze is occasionally required but this should be avoided whenever it may be possible to give sufficient protection against infection by constant cleansing of the mouth and wound surfaces with suitable antiseptic solutions. Moorhead recommends exposing the cyst by raising a flap of periosteum with overlying tissue and suturing this into place again without packing the area of bone excavation.

Multilocular Cysts.—Multilocular cysts may originate through the agency of diseased roots of teeth or follicular odontomas. These collections of cysts sometimes grow to an enormous size as shown in Fig. 302. They result from embryonic inclusion of epithelial cells.

Diagnosis and Prognosis.—In diagnosis such cysts are easily recognized. The prognosis in these cases is more or less doubtful. They sometimes show a tendency to continue to proliferate and grow, especially if not completely removed.

Treatment.—All of the cysts must be removed and a sufficiently large area of surrounding bone, even though resection of the jaw may be necessary, to give protection against recurrence.

Fig. 302.—Multilocular cyst. (Westmoreland.)

Proliferous Cysts.—Proliferous cysts border closely on true tumors in their nature. They may appear in any glandular organ but are most frequently found in the mammary gland and ovary. These cysts contain serous or gelatinous fluid, and occasionally the contents are hemorrhagic in character. They are lined with typical or columnar epithelium and stroma or reticulum of connective tissue. They may be unilocular or multilocular and by communication of the numerous loculi may become cavernous.

Treatment.—Because of the uncertainty of their exact character they should be treated as malignant growths.

Dermoid Cysts.—Simple dermoid cysts may form in any part of the body where epithelial-lined surfaces are united during fetal development. Whenever a sinus that may persist through incomplete development becomes closed at both ends the cavity may be dilated into a cyst by the accumulation of secretions.

Teratomas or Compound Dermoid Cysts.—Teratomas or compound dermoid cysts are lined with epithelium and may contain a variety of structures such as hair, teeth, etc. Fig. 303 shows a dermoid of the neck which by displacement of the tongue and the floor of the mouth made diagnosis quite confusing. Its exact nature was discovered upon removal.

Parasitic Cysts.—Parasitic cysts, such as the hydatid cysts caused by Tænia echinococcus or dog tapeworm, have been found in the mouth in rare instances.

Bertelé reports finding them in the temporal and masseter muscles.[1]

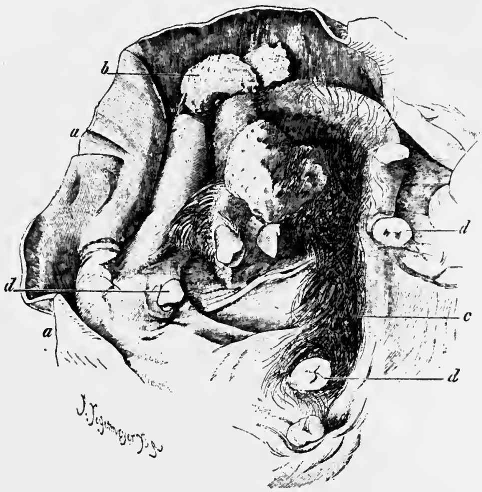


Fig. 303.—Portion of a wall of an ovarian dermoid cyst: *a*, wall of the cyst; *b*, projecting portion made up of fatty and cutaneous tissue; *c*, hairs; *d*, teeth. (Ziegler.)

Odontomas.—An odontoma is defined as a tumor composed of one or more dental tissues arising either from tooth changes or teeth in the process of development. In *classification* Broca divides odontomas according to the stage of development of the dental follicles at which they occur, into embryoplastic when developing in the dental sac, odontoplastic when soft tumors may occur, and a third when the tumors are composed of calcified tooth structures. These again are subdivided into crown and root formation as indicated by their being composed of enamel, dentine, or cementum, or a composite combination of these.

Mallory[2] describes three types of tumors which are recognized as arising from the enamel organ.

"(1) The follicular cyst which is lined with pavement epithelium, the inner wall of which often bears a single and sometimes several cells. (2) Adamantinoma which grows as branching masses of epithelial cells. Those cells adjoining the stroma correspond to adamantoblasts while others form the enamel pulp. They grow expansively only and produce no metastases. (3) Occasionally the adamantinoma produces typical enamel. More often it converts the adjoining fibro-

[1] Bulletin of von Bergmann, p. 521.
[2] Principles of Pathology and Histology.

blasts into odontoblasts. When this happens separate teeth or fused masses of them of various sizes may be produced. Cementum may also be formed."

Some confusion in classification of odontomata occurs by reason of the fact that teeth are developed from epiblastic and mesoblastic structures. For this reason odontoma cannot be classified with the epithelial groups in the strict sense. It is of the adult type and therefore may not be classified with the teratoma or mixed epithelial and connective-tissue tumors because these are both adult and embryonic, whereas the odontoma is adult and therefore benign.

Bland-Sutton[1] classifies odontomes according to the part of the tooth germ from which they appear to originate.

Epithelial Odontomas.—Epithelial odontomas develop in the remains of the epithelium in the original enamel organ.

Symptoms.—They appear in the form of a series of cysts separated by thin septa and contain mucoid fluid. The color during growth is slightly red and not unlike sarcoma.

Fig. 304.—Cyst of the lower jaw, having its origin about an undeveloped tooth. (Garretson.)

Follicular Odontoma or Dentigerous Cyst.—These cysts form in connection with developing permanent teeth.

Symptoms.—The bony walls become thin from the formation of fluid within the cyst and sometimes bulge out in such manner as to cause great deformity. The inner wall of the cyst represents the remains of the dental follicle within which there is a tooth or part of a tooth. The cyst is filled with fluid usually serous or mucoid, but occasionally of dark brown color. Ordinarily they do not become purulent, but occasionally through infection this does occur, and may result in severe inflammatory conditions (Fig. 304).

[1] Tumors, Innocent and Malignant.

Compound Follicular Odontomas.—The follicle wall becomes thickened into a fibrous capsule. In this there may be portions of dentin, enamel, or cementum, combined with more or less imperfectly formed teeth.

Diagnosis.—Myxomatous and fibromatous forms of soft odontoma, both of which are formed during the embryoplastic or odontoplastic periods, are frequently difficult to differentiate from other tumors of the jaw, notably cysts, fibroids, and sarcoma.

The diagnostic guides are slow growth, freedom from pain, irregular surface on section, masses of cement or dentin which may occasionally be found to be encapsuled, and microscopic examination. Of the hard forms, dentigerous cysts are usually discovered by the yielding of the thin bulging wall on pressure, with perhaps a crepitant sound; puncture to reveal the character of the fluid contents, and on opening a tooth is revealed in the cystic enclosure.

Fibrous Odontomas.—Fibrous odontomas are developed from the connective-tissue elements of the developing tooth by excessive growth of the fibrous capsule of the tooth germ which is derived from, and closely adherent to, the connective tissue of the papilla.

Fig. 305.—Fibrous odontome. (Garretson, after Pierce.)

Fig. 306.—Radicular odontome. (Tomes.)

Symptoms.—The tumor has a firm outer wall with less firmly connected inner structure, which at the root of the tooth with the dental papilla is indistinguishable from it. In this way the developing tooth becomes enclosed within the capsule. These tumors are quite frequently seen in animals, especially ruminants, etc. (Fig. 305).

Cementoma.—This is a tumor in which by calcification of the capsule the tooth becomes embedded in a mass of cementum.

Symptoms.—Cementomas sometimes attain great size. Their structure resembles cementum, and is arranged in layers somewhat similar to fibrous odontomas. They are rare in human teeth and usually occur in the mammalia.

Radicular Odontomas.—These tumors form after the development of the crown and during the process of root formation. They consist of cementum and dentin in varying quantities, are rare in man, but frequent in animals (Fig. 306).

Composite Odontomas.—These are abnormal growths of all the elements of tooth structure, resulting in ill-formed masses of cementum, dentin and enamel. Thus far they have been only found in man (Fig. 307).

According to Gilmer:[1] "The composite odontoma differs from the ordinary dentigerous cyst containing diminutive teeth or dentary bodies, in that the dentigerous cyst contains no cement substance other than that which covers the root of the individual tooth, when perfectly formed teeth are found, with each little tooth or denticle separate and distinct from the other; besides there is a well-defined cyst wall and cyst fluid. In the composite odontomes there is no cyst wall or cyst fluid, so far as I have been able to discover."

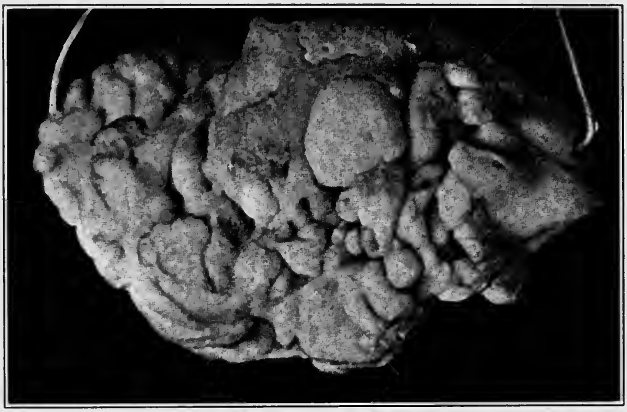


FIG. 307.—Composite odontoma. (Gilmer.)

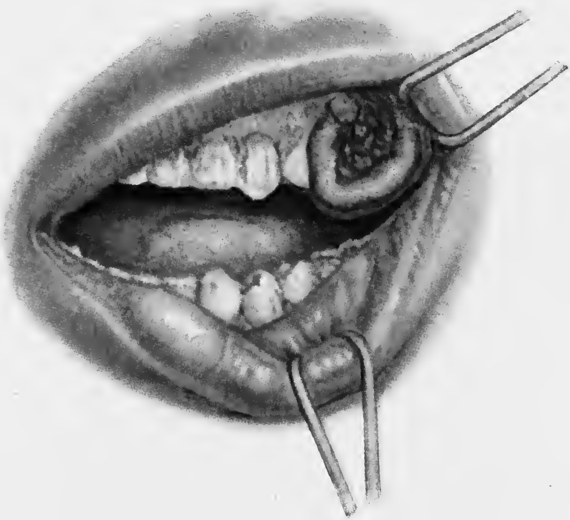
It is interesting to note Dr. Black's report[2] of the histological appearance of sections of a composite odontoma: "I found all the tissues of a normally developed tooth, but in a state of confusion. There is an entire absence of any proper pulp cavity. The disposition or arrangement of the tissues is peculiar and striking. It is as though there were a thousand teeth, exceedingly minute, growing as close together as they could be crowded, and the interstices between them filled up with enamel and cement. In the field of the microscope, with the sections I have, we shall often be able to see a number of these diminutive teeth at a single view. Each has its own little pulp chamber in due form, its own separate dentin and its own enamel cap, and plastered in and about and added on to these there is a considerable amount of both enamel and cement of very irregular formation. Many of the pulp chambers are partially filled with calcospherites. These also appear in many parts of the specimen in profusion."

Odontomas may be recognized by a sharp, light, steel probe passed through the overlying structures until it comes in contact with the dense, more or less irregular surface of the tumor which is recognized by the sense of touch. *Radiograms* give the best evidence of the existence and character of all these tumors.

[1] Report of Six Cases of Composite Odontomas, Jour. Am. Med. Assn., 1911, lvi, 165–168.
[2] Illinois State Dental Society, 1879.

PLATE VIII

FIG. 1



Epulis. (Grünwald.)

FIG. 2

Papilloma of the Gum.

Treatment.—The treatment in all varieties of odontomas consists in their complete removal and destruction of the cyst wall if necessary. The surgeon should always keep in mind the possibility of odontoma in dealing with the maxillary tumors. This is particularly true in cases of children and young persons. In the author's experience upon one occasion it took several hours of careful study and explanation to convince consulting surgeons that resection of the jaw was unnecessary in the case of a boy nine years old some of whose developing teeth in the lower jaw had become encysted, when all that the case required for complete recovery was the removal of the upper wall of the cyst and drainage of the fluid after which the teeth erupted in normal situation and the swelling disappeared. Resection of the mandible always creates more or less deformity under every circumstance, but it is particularly deplorable when required in growing children whose jaws are not yet fully developed for then the unavoidable deformity is very great. There have been notable examples of the resection of such jaws in uncomplicated odontomas.

Epulis.—Epulis is a commonly used, but much confused term employed to distinguish growths which usually originate in the periosteum between or around the necks of the teeth from tooth sockets. (See Plate VIII, Figs. 1–2.) Such a growth might be papilloma, fibroma, carcinoma, sarcoma or any of the tumors which might spring from the fibrous tissue of the gum and periosteum, but it is generally understood to describe giant-cell sarcoma. The difficulty is, however, that giant-cell sarcoma is always a misleading description because as Mallory[1] states: "At least two types of giant cells occur in tumors. One type results from multiple mitoses and signifies rapid growth. It is a true tumor cell with characteristics like the other cells in the tumor in which it is present. This kind of giant cell occurs in a variety of rapidly growing tumors, such, for example, as fibrosarcoma, glioma, lymphoblastoma, carcinoma."

"Giant cells of the second type are found most commonly in new-growths involving bone. They occur both in rapidly-growing and in slow-growing tumors. There are no multiple mitoses to explain their origin.

"Giant cells of this type produce no fibrils. They are foreign body giant cells, similar to the osteoclasts of normal bone and are due to the fusion of endothelial leukocytes attracted into the tumor by the presence chiefly of lime salts which they dissolve and remove. They signify usually disintegration of bone, rarely the presence of fat and fat crystals. They occur most commonly in fibroma and fibrosarcoma involving bone, in the stroma of cancer metastases in bone, and in osteosarcoma."

The importance of this distinction cannot be overestimated. The presence of giant cells alone cannot be depended upon in determining the character of the treatment. (See Plate VIII, Fig. 2.) These

[1] Principles of Pathology and Histology.

growths usually appear upon the gum and give little disturbance outside of the mechanical interference and spread gradually until the surrounding structures are involved.

Diagnosis.—In diagnosis the usual distinction must be made in differentiating from malignant growths. Treatment consists of complete removal down to and including the periosteum with the adjoining teeth as well as those immediately involved, and the removal of sufficient bone to include completely the sockets of the affected teeth. As a matter of precaution it is well to burn the bone surface with a hot iron or cautery. Many of these growths removed in this way by the author have never shown a tendency to recur.

MALPOSED UNERUPTED TEETH.

Through malposition or impaction due to insufficient size of the dental arches, or for other reasons, it is not uncommon to find unerupted teeth in the jaws of adults. These may belong to the normal number of teeth or may be supernumeraries. Their surgical significance is important. Although such teeth may, and sometimes do, remain in a jaw through life without causing noticeable disturbance, they much more frequently become serious, though often unsuspected, causal factors in a considerable number of pathologic affections.

Pathologic Significance.—The tendency of impacted teeth to become encysted and through degenerative changes to become predisposing factors in the establishment of *carcinoma* or *sarcoma* in their surrounding tissues is well known Frequent evidence of this has been given by their discovery during operations for the removal of such growths.

Such teeth sometimes *lie across the paths of large vessels and nerves* and thus become disturbing influences leading to a considerable variety of nervous disorders. In *headaches, neuralgias, spasmodic affections of nervous origin,* and similar conditions their presence in the jaws may bear great etiologic significance.

Alterations in the surrounding bone structure, especially when a tooth is erupted sufficiently to communicate with the surface of the mouth, favor the accumulation of bacteria-laden secretions. In this way *foci of infection* of far-reaching pathologic character may be established. The more or less constant although usually unconscious nervous tension that is caused by the presence of teeth imprisoned in the jaws has frequently given rise to the jaw clinching and tooth grinding habit which has been shown to have an important bearing in some cases of *neurasthenia.* In all disorders, whether local or general in character, in which *peripheral irritation* in the maxillary region may be of diagnostic interest, a careful search should be made for unerupted teeth. Many cases have been reported in which such teeth have been located in the region of the maxillary antrum, or close to the orbit or buried in the nasal septum, or in the floor of the nose, the ramus of the lower jaw and in other unexpected situations (Figs. 308 to 311.) Good has been accomplished by their removal.

FIG. 308.—Impacted teeth in adult case. Deciduous teeth crowned through error on the part of dentist. Chronic disease in this region finally led to diagnosis with the *x*-rays.

FIG. 309.—Unerupted left cuspid near the orbit in the case of a man, aged twenty-six years. Maxillary sinus on left side involved.

FIG. 310.—Two unerupted cuspids situated in the palate of a girl, aged twenty-two years.

Diagnosis.—In examination of the mouth, the number of teeth should always be noted, particularly the presence or absence of fully erupted third molars. Every missing tooth should be accounted for if possible.

Fig. 311.—Radiogram of the mouth of a young woman, aged twenty years, showing an impacted third molar. In this case severe neuralgic pain in the head was relieved by removal of the impacted teeth.

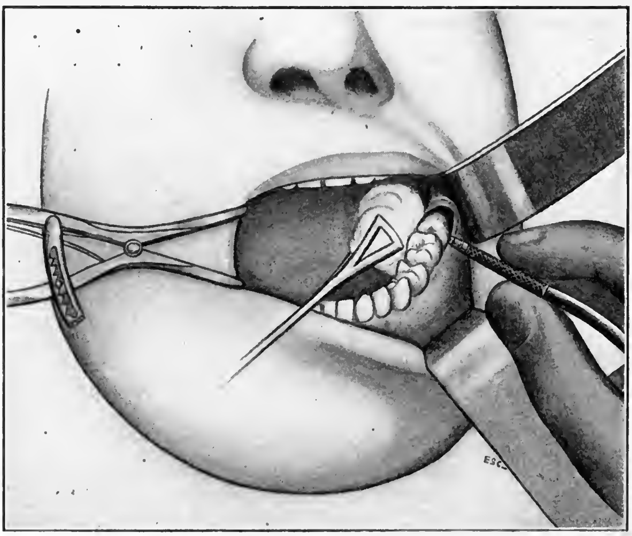


Fig. 312.—This shows the method of controlling the field of operation in extraction of impacted lower teeth. Gauze held between tongue and jaw, retractors and mouth gag in place, and the surface of the impacted lower third molar exposed ready for extraction.

Radiograms give the most positive and also the most accurate results in diagnosticating teeth that may be embedded in the jaws. A sharp-pointed stiff probe may sometimes be passed through the more or less softened overlying bone and once the enamel crown of a tooth is encountered the difference between its hard smooth surface and bone is easily recognized by the sense of touch.

Treatment.—Since these teeth are usually beyond the reach of dental forceps, their surgical removal is required. This may be accomplished under general anesthesia, or by conductive anesthesia through novocain injected at the mandibular foramen, by chiselling the overlying bone or cutting it out with a dental engine but sufficiently to allow the tooth to be grasped with forceps and withdrawn, or after being uncovered it may be lifted out by the use of an elevator of suitable form. Not infrequently a period of more or less serious pain follows the removal of deep-seated impacted teeth because the maxillary nerves may be temporarily exposed. Suitable applications directly to the end of the tooth socket if possible, and the frequent use of antiseptic mouth washes are called for to control the pain and to prevent the extension of infection until complete relief may be given by the healing process (Fig. 312).

MALFORMATIONS OF THE MANDIBLE DUE TO ARRESTED OR PERVERTED DEVELOPMENT.

Prenatal Tendency to Arrest of Maxillary Development.—In the absence of actual deformity such as described on page 577, deficient maxillary development is seldom evidenced at birth. It cannot be denied, however, that some individuals are born with a tendency to insufficient maxillary growth which becoming intensified by postnatal nervous and metabolic conditions leads to many defects of form in this region. Figs. 313 and 314 show congenital malformation of head and face in a child of unusually good mentality and general physical development in all respects.

Diseased Conditions as Malforming Factors.

Endocrine Disorders.—The receding chin and the small jaws of the so-called hypopituitary cases and the prognathous lower jaw attributed to hyperpituitary conditions, as well as the abnormal growth of the mandible in older individuals that is a noticeable symptom of acromegaly, are well recognized as indications of effects which may sometimes be due to other developmental derangements of this character.

Thickening may occur as a result of inflammatory conditions and there may also be alteration in the form or thickness of the bone from infectious diseases such as is found in syphilis, leontiasis ossea, arthritis deformans and other similar affections.

Cysts and *tumors* affecting the osseous structures of the jaws, or in surrounding parts may cause enlargement or absorption and thus give rise to deformities. The loss of bone through necrosis or resections is necessarily followed by the deforming effect of scar tissue contraction

Fig. 313.—Congenital malformation of the head and face of child sixteen months old. Depression in the frontal region on the right side and a corresponding convexity at the occipito-parietal junction on the left side. Marked convexity in the malar region on the right side with corresponding concavity on the left side. Left eye lower than the right; nose, superior maxillary bones and jaw deflected to the left.

Fig. 314.—Same child shown with corrective appliance in place. Head band is adjusted to give freedom for development in the right frontal region with firm compression over the excessively developed parts of the head. Pad to make pressure on right malar convexity with plate in mouth to which the arms are attached from which continuous pressure is made with a rubber band in such manner as to tend to straighten the face and reduce the deformity.

or disarrangement of the bone segments by disordered muscular activity.

Traumatic Injuries.—The lower jaw is much exposed to accidental injuries which cause fractures, and deformities frequently follow imperfect approximation at the seat of fracture, or there may be an alteration in the outline of the mandibular arch by traumatism without fracture.

Loss or Deficiency of Normal Physiologic Activity and Antagonizing Mechanical Influences.—The illustrations of typical forms of the mandible in cases of ankylosis of the temporomandibular articulation as shown in Fig. 315, and the deformities of the lower jaw due to scar contraction for extensive burns in early childhood in Fig. 316, serve to emphasize the influence of both these types of factors in governing the form of the mandible.

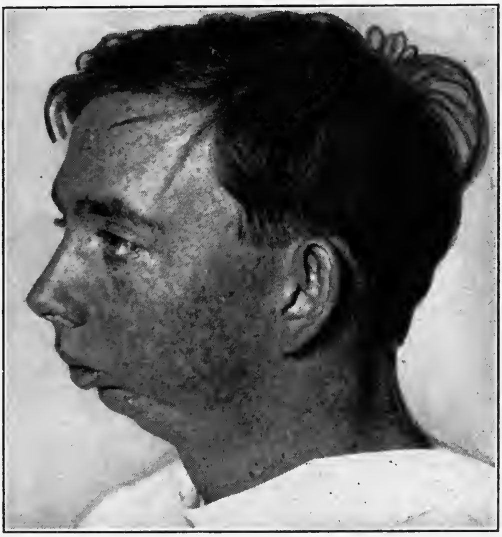


Fig. 315.—Bilateral bony ankylosis.

Surgical Methods of Correction.—When projection of the lower jaw occurs through the forward tension of neck scars as in Fig. 315, or from any other influence which may cause an increase in the thickness of the anterior portion of the body of the mandible as well as in its length, by far the simplest and most satisfactory method of treatment is to expose the jaw by dissecting free the overlying soft tissue from an incision within the mouth, and turning them downward. The exposed portion of the jaw is then cut off in a slanting direction to give the effect of a mental process when the parts are restored to position. Dental bridge-work attached to the remaining teeth on each side of the restricted portion of the jaw is inserted to replace the teeth thus lost. Fig. 317 illustrates the result of this kind of treatment.

Fig. 316.—Man, aged twenty-one years, who was burned in the neck when three years old. Scar tissue caused unusual length and thickness of lower jaw.

Fig. 317.—Same man shown shown in Fig. 316 after operation. The lower jaw was excised from the bicuspid tooth forward and a mental process fashioned out of the thick jaw bone that remained

When the angles of the jaw are too straight there is often occlusion of the molar teeth with wide separation between the incisors. In young persons this defect is sometimes reduced by force applied through suitably adjusted head and chin pieces but in older persons this method of treatment is impracticable. By the extraction of a bicuspid tooth upon each side and the removal of a V-shaped portion of bone from the sockets of these teeth on both sides of the mouth a green-stick fracture may be made without serious consequence, and the chin brought upward into better position. The parts are held in complete fixation by bands attached to the adjoining teeth with connecting bars, nuts and screws as previously described. (See Figs. 320 and 321.)

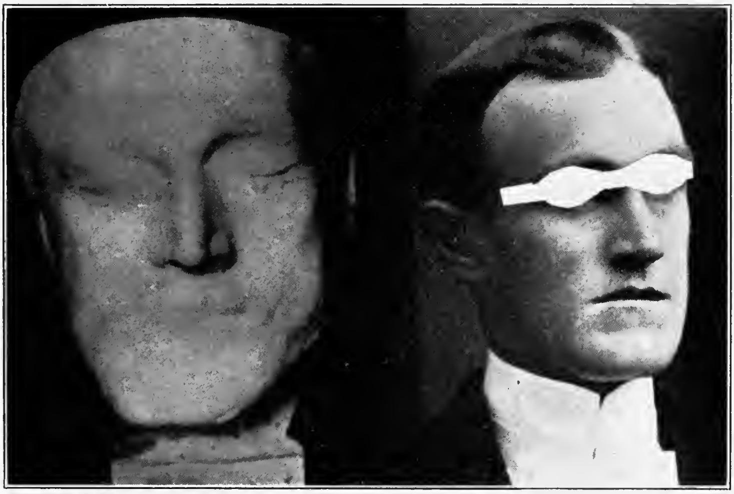


Fig. 318 Fig. 319

Figs. 318 and 319.—Cast of the face of a young man, for whom the author removed a section from one side of the lower jaw, as shown in Fig. 318. This picture is shown through the courtesy of Dr. Joseph Eby, of Atlanta, Ga., who made the cast.

The shortening of the jaws by this treatment is sometimes objectionable and under these circumstances, the author believes that, notwithstanding the small external scars, this might be accomplished more successfully by cutting through the lower border of the jaw, after making an incision through the skin, separating the intervening tissues and the periosteum, to avoid mouth infection, then forcing the anterior teeth into contact and holding them in position with suitable splints attached to both jaws.

Defective Tooth Eruption.—This is altogether the most frequent cause of both upper maxillary and mandibular defective form. Sometimes the germs of teeth are missing or teeth may remain embedded in the jaws without eruption, or be erupted on the lingual or buccal aspects (within or without) the line of the dental arch; or their early extraction may have caused the same effect. Without the stimulation of developmental activity that is induced by the crowns of the teeth as they are forced into their normal situations in the course of natural eruption the maxillary structures do not grow as they otherwise would.

Treatment.—The effect of absence or disarrangement of the teeth may be largely overcome by the well-known methods employed by orthodontists. More radical surgical procedures should not be attempted if the defect can be overcome by this slower but very effective and in the end probably much more beneficial plan of treatment. To the surgeon who is usually more or less unfamiliar with the principles of orthodontia the following outline of the reasonable limitations of such methods may be useful.

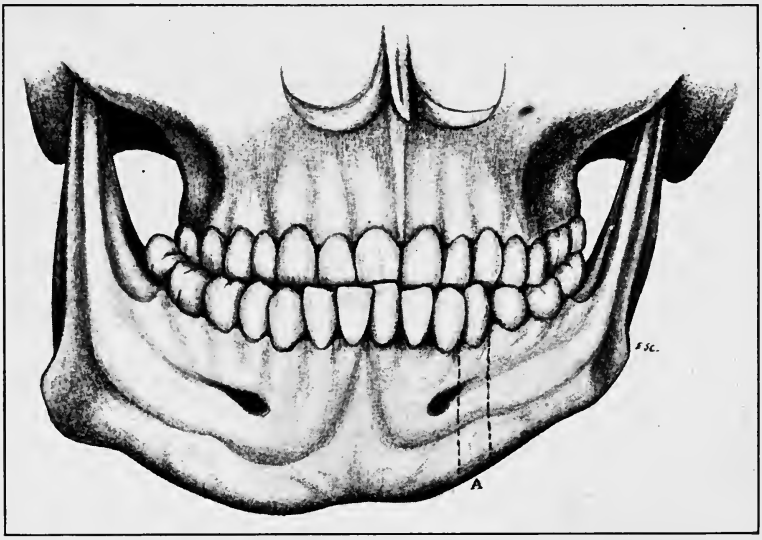


Fig. 320.—Drawing showing the deformity of the jaws of the young man, a cast of whose face is shown in Fig. 335. The dotted line indicates where the second bicuspid tooth and a section of bone completely through the jaw was removed by the use of a saw and engine bur.

Marked recession of the chin and apparent insufficiency in size of the lower jaw may be due in considerable measure to distal malocclusion so that the teeth of the lower jaw come in contact with the upper teeth farther back than they properly should. By the use of intermaxillary rubbers and in various other ways orthodontists are accustomed to force these jaws forward with marked beneficial affect. Much enlargement of the dental arch with corresponding improvement in the outline of the mandible may be accomplished by the use of orthodontic appliances. Space thus secured for the eruption of unerupted teeth in crowded dental arches is usually followed by their prompt appearance. When this does not occur further growth into position can be stimulated by the application of gentle force. The general growth in size of the lower jaw may be greatly stimulated by steadily applied pressure from suitable appliances. Beyond this the grosser deformities require surgical interference.

The maxillary irregularities which may be prevented or improved by treatment are necessarily the ones about which surgical interest centers. The possible importance of endocrine disorders in this relation must be appreciated, but present knowledge of this form of therapy is too insufficient to warrant definite statements with regard to prophylactic measures in this direction.

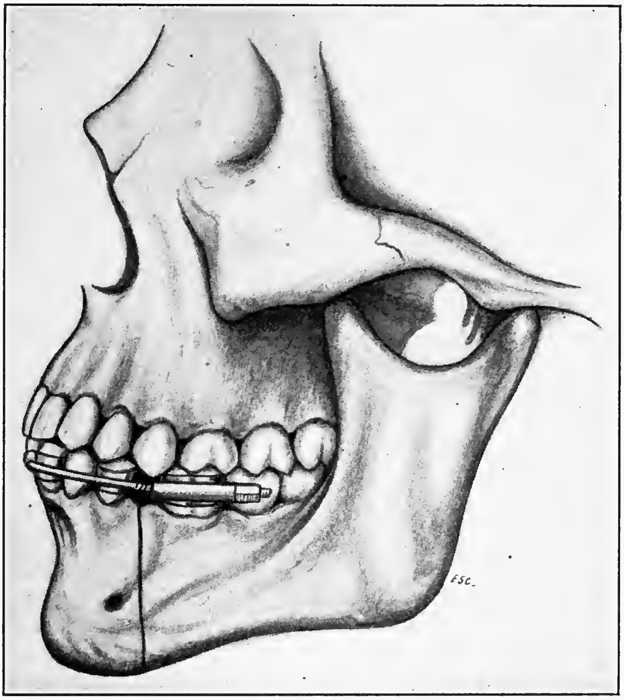


Fig. 321.—Shows drawing of the jaws as they were in the cast illustrated in Figs. 318 and 319 after removal of a second bicuspid tooth and complete resection of the jaw, the approximation of the bone ends and fixation with an appliance attached with metal bands cemented to the teeth and adjusted by a nut tightened upon a thread cut in the bar of the appliance. In most cases the metal band shown attached to the molar next to the point of excision would be better attached one tooth farther back. The situation of the bands must necessarily be determined by the condition of the case.

Prognathous Lower Jaw.—In undertaking surgical treatment for the reduction of prognathism of the lower jaw it must be understood that in many cases this deformity is not due to an excessively large lower jaw so much as it is to an arrested development of the upper jaw which is usually associated with a contracted upper dental arch and its invariably accompanying high narrow palatal vault.

Bilateral Resections to Reduce Prognathous Lower Jaws.—The removal of a segment from each side of the body of the lower jaw, as performed by Blair and reported by Angle,[1] has since been improved

[1] Blair's Surgery of the Diseases of the Mouth and Jaws, p 308.

by Blair who has perfected a method of performing a submucous periosteal operation for the removal of a section of bone on each side of the jaw and fixation of the parts with a splint covering the crowns, lingual and buccal surfaces of the teeth, made in three sections and cemented before the operation so that they may be fastened immediately upon removal of the bone segments.

Blair believes that the jaw should also be wired near the lower border to give additional security. Babcock cuts through the rami of the jaw, slides the body back, and fastens it in this position. Harsha cuts sections from the angle on each side, and thus accomplishes the necessary shortening.

Unfortunately both the cases reported by Babcock and Harsha appeared to the author to have been of such character that much better results could have been obtained by expansion of the undersized upper jaw rather than by reduction of the lower and with a distinct benefit to respiration and health by such expansion.

Deformities of the Jaw due to Tumor Growths and Tumor Pressure.—When the outline of the lower jaw has been deformed by tumor growth and tumor pressure, much may be done by careful separation of the overlying periosteum, and the removal of the redundant bone structures sufficiently to restore symmetrical outlines. The periosteum is then replaced. Notwithstanding the unavoidable oral infectious influences the results in such cases are usually gratifying.

Unilateral Resection.—When one side of the lower jaw is longer than the other it can be reduced with immediate improvement in the appearance of the individual.

The author's method of performing this operation is to prepare and cement to the teeth at each side of the portion to be revised, a splint made of metal bands attached to the second tooth beyond the one next to the incision on each side. These are connected by screws and nuts on both their lingual and buccal aspects. When the section of bone is resected, the nuts are tightened until the bone ends are held firmly and perfectly in contact. The result is absolutely exact and there is a minimum of postoperative discomfort.

In the same way the author also lengthens one side of the lower jaw only, in this case the turning of the nuts forces the several bones apart, and holds them during the filling in of bone substance between them. Absolute fixation is the essential thing in each case.

Extension on the Lower Jaw.—The loss of a section of bone through necrosis, resection, accidental injury, gunshot wounds, etc., may require extension to overcome the deformity resulting from the excessive retraction. Bone grafting has given good results in these cases, as described on page 643 and illustrated in Figs. 452 to 462.

The Correction of Related Nasal and Maxillary Developmental Defects by Separation of the Superior Maxillæ.—Etiology.—Deflections of the nasal septum, contracted nares, high narrow palates and irregular dental arches, are frequently coincident among children who present the usual clinical picture of adenoids, enlarged tonsils, mouth breathing and a tendency to nasal and bronchial diseased conditions as well as the mental and nervous characteristics which are typical of such individuals. This leads to the belief that there is an important underlying developmental influence which is accountable for the association cf these defects. The mechanical effects of such malformations favor the wrong appplication of the force of muscular activities, and the restriction of natural function which must also be considered in determining methods of surgical correction.

The *prenatal influences* which relate to heredity, metabolism, diseased conditions of the parents and similar factors are of undoubted importance, but the prophylaxis which might be influential in overcoming such predisposition necessarily lies outside the field of surgery.

The *postnatal* results of irregular or perverted development due to abnormal muscular activities, obstructions of the upper air passages, and similar influences require operative treatment to prevent the extension of such ill effects, and to restore normal functional activities.

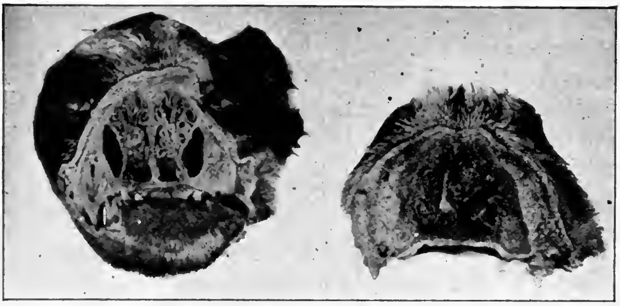
The influence of the *endocrine organs* upon the form and character of bodily growth, metabolic changes, and nervous and mental states, as indicated by diseases of and animal experimentation upon the hypophysis, thyroid, thymus and pineal glands, the testes, ovaries, and other members of this group, forms the basis of therapeutic efforts in this direction. There appears to be a high degree of susceptibility to very finely balanced chemical influences to which the entire endocrine organ system is subject. With this in mind one can better understand how irregular dental arches and high, narrow palates may primarily be due to the same etiologic influences as the greater deformities noted in acromegaly and other diseases showing marked variations from normal growth.

Proof of the effect of mechanical restriction of growth in width across the palates of dogs as influencing the size of the nares the form of their nasal septa, and the character of the nasal accessory sinuses is shown in Figs. 322 and 323. The results were identical in all the pups similarly treated.

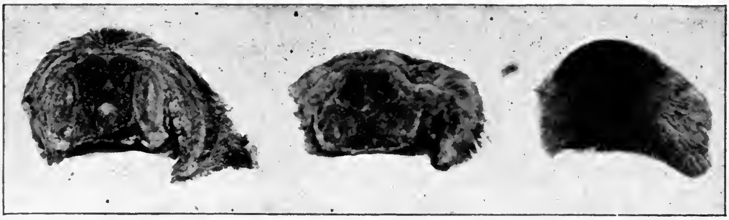
The dependence of dogs upon healthful nasal conditions is vital because it is only under great stress that any air can be inspired through their mouths. For this reason regularity in the form of the septum, nares, and nasal accessory sinuses is the rule among all such animals.

Symptoms Shown by Pups Similar to those of Human Patients.—All the pups so treated developed the following symptoms, which are identical with those commonly found in children with high, contracted palates and irregular upper dental arches, viz., a high degree of susceptibility to infection, which was evidenced by congested bronchi and lungs, and was in marked contrast to the usually notable resistance to pathogenic bacteria of the bronchial mucous membrane in healthy dogs, and quite in accord with frequent colds, bronchitis, and tendency to pneumonic affections that are characteristic of all mouth-breathing children.

Extreme nervousness was also similar to children of this type. The

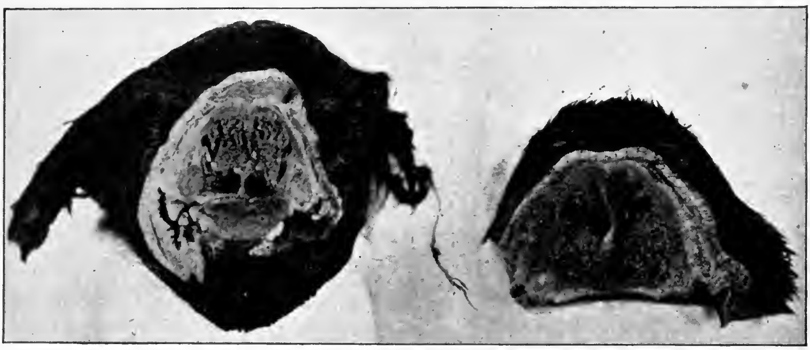


A *B*



C *D* *E*

FIG. 322.—Sections of head of puppy six months old, with jaws arrested in development across the palate by wiring at eight weeks old. These sections when compared with those of a normal pup shown in Fig. 323 show plainly the contracted effect upon the nares, the deviation of the nasal septum—especially the section shown in *C*, the point at which the wire was inserted and development arrested. The enlarged maxillary sinuses are also evident in comparison.



A *B*

C *D* *E*

FIG. 323.—Control pup, same age as Fig. 322, upon which no operation was performed.

nasal accessory sinuses became enlarged. This is particularly evident in the maxillary sinuses as shown in Fig 321. The experiment pups became emaciated and were not nearly so large and fat as the control pup, although given the same food. Making all due allowance for impure breed, there was still evident a considerable interference with trophic changes.

Inasmuch as questions of heredity, eugenics, and so-called degenerate tendencies which always perplex the consideration of etiology in human subjects of this character may be ruled out in dealing with dogs, the importance of these results when applied to the treatment of children is proportionately increased. Since deflections of the nasal septum almost invariably result in dogs and among children when there is insufficient breadth across the upper jaw, with a corresponding high narrow palatal vault, obviously the first step toward correction of this nasal deflection should be a sufficient restoration in the width of the upper dental arch. This may be accomplished as indicated in Fig. 345 by separation of the upper maxillæ through the median palatine suture by the use of an appliance attached to the teeth on each side of the mouth with bands cemented into place and connected by rigid side bars resting against the lingual sides of as many teeth as possible on each side and connected by a combination of a tube, screw and nut across the most contracted portion of the palate, adjusted so that when the nut is turned, pressure will be exerted to force the maxillary bones apart. Turning such a nut twice a day, morning and evening sufficiently to make strong pressure, will usually spread the upper maxillary bones by separation through this median palatine suture and through their attachment to the nasal processes, the nasal bones are also moved.

By this procedure all the necessary intranasal space that may be required for comfortable respiration may usually be secured in from ten days' to two weeks' time in persons up to approximately thirty years of age. Quite naturally the younger the patients are, the more easily this may be accomplished. Occasionally the median palatine suture does not become entirely closed until after middle life and in such cases the same result may sometimes be obtained for persons who are more than thirty years old.

The Immediate Surgical Separation of the Superior Maxillary Bones to Widen the Nares for the Improvement of Respiratory and Other Conditions According to the Author's Operation.—The day before the operation is performed an expansion splint is cemented to the teeth. This appliance is in all respects the same as previously described for the slower method of non-surgical rapid maxillary separation, except that when possible additional bands are cemented on both second bicuspid teeth and hooks to slide over the side bars to give greater firmness.

Under general anesthesia the upper lip is raised and a vertical incision about three-eighths of an inch long in the median line above and between the roots of the central incisor teeth is carried down to the bone close to the frenum labialis superioris. The periosteum is then slightly raised on each side of the incision and the tissues retracted to expose the intermaxillary suture.

A fine chisel is inserted into the suture at this point, and followed with a larger, more wedge-shaped chisel. A few blows with a mallet forces the chisel between the bones and by tightening the screw of the mouth appliance the separation is made complete (see Figs. 324 to 326).

In this way the maxillæ are forced apart, carrying with them the attached nasal bones. The result is a direct increase in size of the nares.

The almost instantaneous effect of forcing the maxillæ apart after surgical separation appears to exert a more pronounced influence in the graver types of cases than the slower method of depending upon pressure against the teeth alone as in non-surgical rapid expansion of the upper dental arch. The freer bone movement thus allowed gives

Fig. 324.—Shows splint in place with expansion screw bar across the palate. Vertical incision as made above and between the roots of the central incised teeth down to the bone at the intermaxillary suture.

less tendency to flanging of the teeth, and the relation of intranasal enlargement to the increased width across is proportionately improved.

With the restoration of nasal respiration and the cessation of mouth breathing which usually follows quite naturally when the nares are thus enlarged, permanent improvement in intranasal conditions almost invariably results. The reduction of hypertrophic conditions and thus gaining freer opening of the ostea of the nasal accessory sinuses, better drainage and aëration of the ethmoidal, frontal, sphenoidal and maxillary cells and sinuses is permitted. This may give far-reaching benefit, and there is usually marked tendency toward healthful disappearance of both adenoids and enlarged tonsils under these conditions.

FIG. 325.—Chisel at the intermaxillary suture being driven between the bones by gentle blows with a mallet.

FIG. 326.—Turning the nut on the cross bar of the appliance after the maxillary bones have been partially set free by separation through their intermaxillary and median palatine sutures. The space between the central incisor teeth which are not touched by the appliance indicates the complete accomplishment of the separation of the maxillæ. By turning the nut during the first few days after the operation as much enlargement as necessary may be secured. It is therefore both undesirable and unnecessary to apply much force with the expansion screw during the operation while the patient is unconscious. In this way any possible danger of injury to the teeth is avoided.

Notwithstanding the generally recognized importance of diseased tonsils as foci of infection which may lead to serious though remotely situated disease, many operators feel that tonsillectomy should not be performed except for good and sufficient reasons as in the presence of actual disease, evidenced by repeated attacks of tonsillitis or some equally grave disturbance. The question of precedence in determining whether the adenoids and tonsils should first be removed and then the nares widened, or the nares given opportunity for the natural restoration of healthful tonsillar conditions before tonsillectomy and adenectomy are performed, is sometimes difficult to decide. There can, however, be no question but that the future health of both nose and pharynx depends upon restoration of sufficient space to permit the permanent establishment of free nasal respiration.

When the upper maxillæ are spread apart and the intranasal space increased, the septal straightening through its natural resiliency is frequently so marked as to make correction of the deflection by resection quite unnecessary, but when this deformity is too great or of such long standing that complete relief cannot be given in this way, then the usual operation for resection must be performed. Even though operation upon the septum may be necessary, the extent of the required resection will be much less and the operative conditions much more favorable to a permanent benefit after maxillary expansion has been previously employed.

The Indications of a Distinctive Governing Developmental Influence.—Among patients referred to me by rhinologists for maxillary expansion to correct pathological states coincident with contracted nares and deflected nasal septa, who have also high, narrow palatal vaults, irregular dental arches, adenoids, enlarged tonsils, and typical mouth-breathing, I have found upon more general examination that in a large number of cases their backs were also irregularly formed, one shoulder blade being larger than the other and one of them higher or lower, with a tendency to curvature of the spinal column. The hands and feet also quite frequently showed irregularities. In the hand, palmar wasting and an enlarged thumb were sometimes conspicuously evident. One side of the face was sometimes found to be more developed than the other, the unilateral asymmetry being quite outside of that which might be expected from irregular teeth alone. These features bore a striking resemblance to the recognized indications of muscular dystrophy, which in its progressive form leads to weakness and actual loss of usefulness in muscles of the affected regions, and which may end in death, or in some mysterious way become arrested, leaving the muscles in a state of partial usefulness.

Following the maxillary separation by rapid expansion in individuals presenting the clinical picture I have described, there is manifested in addition to the relief of freer nasal respiration and better nasal accessory sinus drainage, an influence upon nerve tension that tends to bring about a general improvement in nervous conditions. This is many times an active factor in helping to overcome a tendency to habits such as winking of the eyelids or similar involuntary acts that simulate the beginning of spasmodic affections. An almost innumerable list of other evidences of unstable nervous tendencies could be described if necessary. Notable examples of these are referred to in connection with the illustrations. The dulness and apathy which are not only pathognomonic of mouth-breathers, but of serious nervous states as well, seem to disappear. These patients do better in their school or college work after this treatment than before.

Increased growth or weight indicates that the centers governing trophic changes have been stimulated. How much of all this progressive effect the improved respiration, unaided by any other factor, may be responsible for, it is difficult to say, but it is reasonable to assume that the vital and final influence lies much deeper. In a prophylactic sense there is almost unlimited opportunity for expansion in the region of the jaws and face to give greater developmental freedom at the base of the skull in younger children, thereby favoring more perfect conditions pertaining to the large foramina, through which the cranial nerves and accompanying vessels must emerge, and compression of which under disturbed conditions might be favored by imperfect development.

As is well known, children who are mouth-breathers because of adenoids, enlarged tonsils, or arrested or perverted nasal development, are frequent sufferers from coughs, colds, and other evidences of infectious processes in this region. The same is true with older persons in corresponding degree.

With the development of knowledge pertaining to the vegetative nervous system and the far-reaching effect upon physiological and pathological phenomena that are controlled by the counteracting adjustment of the balance between the sympathetic and vagus systems, much that has hitherto been etiologically and pathologically obscure is rapidly coming to be better understood, and this is particularly true of treatment by jaw expansion.

It is well known that "The vagus system supplies the large glands of the abdominal cavity, the lower two-thirds of the esophagus, the stomach, and the intestines as far as the descending colon. The sympathetic supplies the tract from one end to the other.

"The ganglion cells of the walls of the intestines control this movement of the intestinal organs, but the sympathetic and the vagus exercise the regulatory functions of acceleration or inhibition.

"The vagus nerve through its depressor nerve exercises an inhibitory action on the heart, while the sympathetic through its acceleration nerves has acceleration functions. In the digestive tract this is reversed: The vagus accelerates. The sympathetic inhibits."

Higler[1] calls attention to the important significance of the existence of the following structures: (*a*) Ciliary ganglion lying in the posterior part of the orbit which supplies the sphincter iridis and the ciliary

[1] Vegetative Neurology, Jour. Ment. and Nerv. Dis.; translation by Walter Max Kraus, New York.

muscle; (*b*) the sphenopalatine ganglia lying on the pterygopalatine fossa which supplies the lacrimal gland and the mucous glands of the nasopharynx; (*c*) the otic ganglia lying under the foramen ovale which supplies the parotid gland; (*d*) the submaxillary and sublingual ganglia which supply the corresponding glands; (*e*) the automatic ganglia (the bulbar part of the vagus domain) which lie in organs and which supply the glands and muscles of the trachea, the heart muscle, and the gastro-intestinal tract from the mouth to the descending colon; (*f*) the ganglion mesentericum inferium, hypogastricum, and hemorrhoidale which lie in the upper and lower parts of the pelvis, supplying the muscles and glands of the descending colon, the sigmoid, the anus the genital apparatus, and the bloodvessels belonging thereunto.

The Immediate Effect of Maxillary Separation.—The patients themselves almost invariably recognize the difference in nasal breathing, and this improvement occurs when other evidences indicate that the nose has been widened and the volume of air correspondingly increased at each inhalation. The degree of the change is naturally governed by the condition of the nasal mucous membrane, which may be rapid or slow or variable in its response.

Fig. 327.—Skiagram of the mouth of a girl. aged eight years, showing appliance in place but before pressure has been applied —taken June 29, 1913.

Fig. 328.—The same mouth July 29, 1913. This result might have been secured much earlier except for delays which occurred by the patient's being out of the city.

Patients also commonly report feeling the effect of pressure high up in the nasal and maxillary regions when the nut is turned tightly after the maxillæ have been separated.

Rhinologists' examinations almost invariably disclose that there has been an immediate enlargement of the breathing-space. Practically all such patients in my practice are referred to rhinologists for examination as soon as the incisors are moved apart sufficiently to warrant the belief that there has been a noticeable change within the nose.

The *x*-ray invariably gives pictures such as Figs. 327 and 328.

Fig. 330 shows the radiograph of the central portion of the palate of a man, aged twenty-eight years, whose upper maxillæ were widely separated because of marked intranasal deformity and nasal disease associated with pathologic conditions of the nasal accessory sinuses and a debilitated general state which precluded active physical effort. All these symptoms have since almost entirely disappeared. This radiograph, taken two years after his mouth was expanded, shows a dark, broad line which seems to indicate that bone had been developed along the line of the interspace between the bones separated through the median maxillary suture, just as one would be led to expect would occur under any other similar conditions.

Fig. 329

Fig. 330

Fig. 329.—Skiagram of the mouth of a boy, aged twelve years, who was a chronic sufferer from hay fever, headaches, bronchitis, and general nervous conditions, particularly noticeable in winking of the eyelids. Marked improvement in all these symptoms followed widening of his upper dental arch in July, 1912. The skiagram of his palate was taken January 11, 1913. The thick black line along the line of the median palatine suture seems to indicate new bone formation in that region. During these six months his growth in height was increased two and three-quarter inches.

Fig. 330.—Skiagram of the palate of a young man, aged twenty-eight years, for whom wide separation of the median palatine suture was performed, with great benefit to nasal and general pathologic conditions; taken two years afterward. The thick dark line shown where new bone had formed in the line of the formerly separated median palatine suture, proves that the osteogenetic layer of the palatal periosteum does become active under these conditions and that new bone formation results.

HARELIP.

Development.—At approximately the third week the mandibular arches of the fetus appear. In due course from these the maxillary processes grow forward and the olfactory pits of the frontonasal processes appear to prepare for the formation of the nostrils at about the fifth week. The globular processes unite to form the philtrum of the upper lip, and when joined to the lateral nasal processes they also give rise to the alæ nasi. By fusion of the globular processes at approximately the eight week the upper lip is formed.

Division between the nose and mouth occurs through development of the premaxillary portion of the palate from the globular processes and the remainder of the palate from the maxillary processes. Extending inward toward the central line and backward the complete formation of these parts is accomplished and fusion of the premaxillæ brought about at approximately the ninth week. Thus it may be seen that the failure of union in any of these parts would give rise to the different forms of harelip and cleft palate (Fig. 331).

Etiology.—The same influences that pertain to other developmental defects are also potent in the causation of these deformities. Hered-

Fig. 331.—Section through the head of a human embryo at approximately the fifth week. (Latham.)

Fig. 332.—Double development of the nasal septum, with central groove through nose and median fissure of the upper lip and palate.

ity, consanguinity, syphilis, imperfect metabolism, endocrine organ disorders, and pathological affections of the female generative organs through misplacement, defective form or inflammatory conditions, and unstable nervous states may each be entitled to consideration as predisposing or direct factors.

The exact importance of hereditary influences in this regard is difficult to determine. The family histories of many hundreds of these cases that have come under the author's observation when considered in a general way seem to show only a small percentage (approximately 10 per cent.) in which it could be determined that blood relations were similarly affected; but in the southern States, where family histories are more easily recorded and where consanguinity might also be expected to be a notable factor because of the somewhat frequent intermarriage of more or less directly related individuals, heredity appears to be influential much more frequently than among children born in the northern and western States.

Fig. 333.—Complete bilateral fissure (coloboma) of face. (Guersant.)

Varieties.—The most common forms of lip fissure are *single harelip,* in which there is a division on the right or left side of the median line, and *double* cases with fissures on both sides of the upper lip (Figs. 334, 336, 338, and 339).

Single median fissures sometimes occur (Fig. 332) and either single or double fissures may extend completely through the face up to the orbits (Fig. 333), or be associated with cyclops and other extensive deformities. Fissures of the lower lip and jaw appear less frequently than upper lip defects, and in rare instances there is a cleft chin due to failure in the union of the two inferior maxillary arches. The precarious condition of infants with extensive facial fissures usually renders operative assistance a matter of such great uncertainty as to be almost useless. Attempts in this direction should be by extension and adaptation of the methods employed in the treatment of more simple cases.

Fig. 334.—Single harelip (2d degree).

Fig. 335.—The same child as shown in Fig. 334 after operation.

Fissures of the lower lip require essentially the same treatment as upper lip fissures in reverse order. Failure of union in the median line of the lower jaw may require that the bones be united to permit continuous growth, and later treatment in the form of extension and expansion of the lower jaw by the use of appliances to restore its sym-

Fig. 336.—Single harelip (3d degree). In this case there was a cleft through both hard and soft palates.

Fig. 337.—Same child as shown in Fig. 336 after both lip and palate fissures have been closed by operation.

metrical appearance and usefulness. The growth and form of such a jaw may be much improved by the properly directed pressure of orthodontic and orthopedic methods.

Harelips are usually described as of first degree when the fissure involves only a portion of the lip, second degree when the cleft includes the entire length of the lip from the prolabium to the nose, and third degree those in which wide fissures extend completely through the lip and include also the alveolar and palatal bone structures.

Congenital Lip Scars may occur on one or both sides of the lip. Such white marks usually follow the lines of harelip fissures and may or may not be associated with prolabial defects. Notwithstanding their simple appearance such scars are among the most difficult of all lip imperfections to remove with good cosmetic effect.

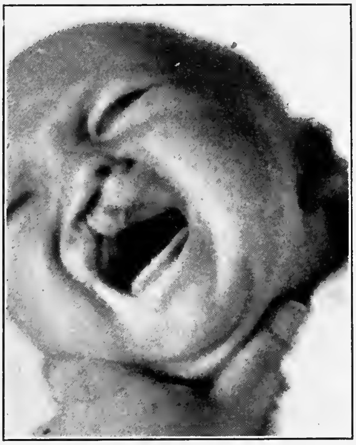


Fig. 338.—Infant with single harelip (3d degree) and wide fissure through both hard and soft palates, showing characteristic deformity of nose and mouth.

Fig. 339.—Same baby at eight months of age, after lip and hard palate have been closed as described.

The Time and Character of the First Operation When Both Lip and Palate are Involved.—The right settlement of this distressing question is a matter of vital importance to the parents of such a child and also to the physician in charge of the case. There are many reasons why good results can be secured by closing the lip first and the palate afterward that cannot be obtained by reversing this order of procedure, or in attempting to close both lip and palate at the same operation. When both are closed simultaneously it is impossible to properly care for either after operation, therefore the palate must be neglected to prevent injury to the lip, and the lip is constantly in danger of infection from the palate. Figs. 357 and 361 illustrate some of the disastrous results of this treatment.

Principles of Cheiloplasty and Staphylorrhaphy.—The essential features of harelip and cleft palate treatment may be summed up under two heads.

The Preservation of Natural Anatomical Relation and Fostering Normal Development.—When a single fissure extends completely through the hard palate, the alveolar ridge and the lip surface it is usually deflected to the right or left in the line of the premaxillary suture. (A division straight through the central line between the premaxillæ is of rare occurrence.) The premaxilla is thus projected forward and to the opposite side with corresponding deformities of the nasal septum, the triangular cartilage, the nose, and the ala on the affected side. If associated with double harelip the premaxilla is more or less completely free from lateral maxillary attachment, and through the lack of restraining muscular influences projects forward and upward. The result of this invariably leads to insufficient development of the columna of the nose and an excessive growth of the nasal septum and the vomer with flatness of the cartilaginous wings of the nose upon both sides. The segments of the upper jaw even at birth contain the germs of nearly all of both the deciduous and permanent sets of teeth. It is obvious then that to preserve the form of the palate and the dental arches upon which both cosmetic effect and speech depend, these parts should be brought into natural relation as closely as possible (Fig. 340).

FIG. 340.—Infant with double harelip; shows characteristic projection of the premaxilla, and philtrum of the upper lip.

Operative Methods.—A comprehensive idea of the management of harelip and cleft palate cases may best be given by consideration of the class of cases in which the fissure extends completely through both hard and soft palates, the alveolar ridge and lip.

First Aid.—If operation cannot be performed immediately then as soon as possible after birth a strip of adhesive plaster should be placed across the lip fissure as shown in Fig. 341. This should be narrow where it crosses the lip and wide at each end to give sufficient skin resistance. It should be tight enough to insure tension, so that when this is intensified as the child cries or smiles it will reduce the width of the fissure. Immediate control of the parts in this way prevents increase of the nasal deformity and further widening of the

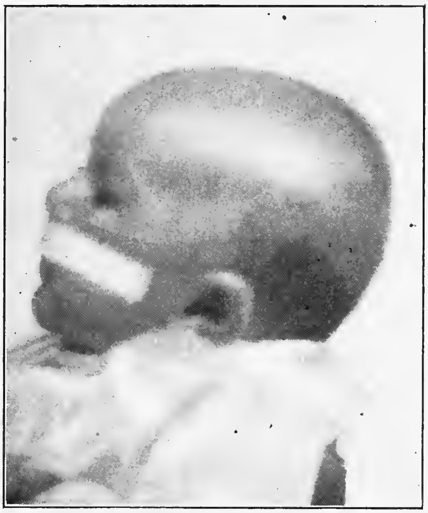


Fig. 341.—Same infant as in Fig. 340 with adhesive strip adjusted to reduce the deformity as described in the test.

lip and palate fissures by adverse muscular action. The same muscles are thus employed to reduce instead of increase these deformities. The child breathes better from the beginning and can take nourishment more advantageously. Figs. 342 and 343 show how much may be accomplished in a short time by such fixation.

Fig. 342.—Same infant as in Figs. 340 and 341. Front view before operation shows the benefit derived from wearing the adhesive strip for about ten days.

Age of Harelip Operation.—The conditions which must govern the determination of the age at which harelip operation should be done are opportunity and the condition of the child. Whenever possible the lip should be closed upon the day of birth or at the earliest possible time that circumstances will permit. Decision in this respect must be subject to the condition of the health of the infant. It may be necessary to perform an immediate operation in order to improve its ability to take nourishment thus increasing the possibility of improved health, or the child's condition may be so precarious as to preclude operation of any kind until its strength may become sufficient to insure better operative resistance. In newborn infants this is seldom a matter of great importance, but after the first few weeks, when there may be evidence of malnutrition and bottle-feeding difficulties, it is

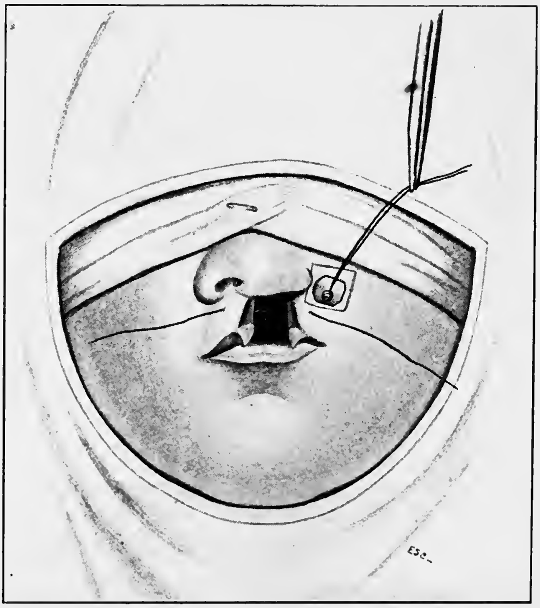


FIG. 343.—The author's method of single harelip operation. Fissure borders denuded and split; the prolabium flaps prepared for suturing; the first control suture in place.

sometimes an exceedingly difficult matter to decide. Good results can be secured at any time within the first two or three months and even at six months old or later, although such delay should be avoided if possible.

Position During Operation.—The arms are bound close to the sides of the body by wrappings which may be warm but not too tight. A warm-water bottle under the legs and buttocks gives necessary heat sustenance, reduces tendency to shock, and rests that portion of the body. A pillow or small sand-bag under the shoulders causes the head to drop backward and gives a better view of the field of operation. This position also reduces the likelihood of blood inspiration. After proper cleansing of the skin surfaces and the nose and mouth, a strip of folded gauze, such as is used for gauze drains is packed lightly into the fissure and loosely placed between the jaws in such manner that it may not cause distortion of the external parts or interfere with the operation, but may check the flow of blood into the throat and still be sufficiently loose to permit the free inspiration of air.

Fixation of the Nasal Septum and Ala.—The author carries a silkworm-gut suture, with a silver splint attached to it, through the nasal septum, beneath the cartilaginous wing of the nose out upon the cheek close to the nasolabial angle, where it is fixed by the use of a silver plate fastened with a perforated shot clamped on the wire. To prevent irritation from the silver plate a strip of adhesive plaster, with a hole in the center, to permit the wire to pass through it, is first laid upon the skin surface. This combination of splint and suture serves to hold the parts in the right position. It also relieves tension during the healing of the wound and is very effective in aiding the control of hemorrhage during the operation.

Lip Compression Clamps.—Hemorrhage from the coronary arteries of the lip is controlled by simple spring clamps that are easily and quickly adjusted. Before they are placed, however, it must be remembered there is often a great difference in both the length and thickness of the lip tissues upon each side of the fissure. It is therefore important that approximate measurements be made and the length of the incision estimated upon the outline of the parts before they are distorted in any way by the adjustment of clamps.

Lines of Incision.—The points at which the skin incision must begin and end should be fixed by the attachment of small forceps. Allowance should be made at the border of the skin and prolabium so that the length of the lip in the line of the incision may be such as to give a symmetrical outline to the mouth. In making this estimate there are a few considerations that are of vital importance: If the line of the lip approximation when completed be ever so little too long it will result in a tendency to draw downward and inward. As the child grows older this will cause the lip to become unusually long, and will bring about the unsightly rabbit-like appearance which may be noted in Figs. 365 to 367. If, on the other hand, the incisions are not carried sufficiently far and thus do not include the requisite amount of lip surface, the lip at this point will be short and the unsightly notch that is so often associated with these cases will mar the effect of the operation. It is failure in this respect more often than scar contraction that leads to this form of postoperative lip defect. The incision in every case should be as simple in form as possible. Unfortunately the literature of this subject supplies innumerable descriptions of more or less complicated methods of making incisions to adjust malformed lips of this character. The illustrations that accompany them are often very elaborate, but the author's experience with many hundred of these cases warrants the statement that the greatest possible benefit can only be secured in proportion to the simplicity and direct purpose of the lines of incision. Any adjustment of the lip fissure borders which contemplates even the slightest degree of malposition of important muscular fibers no matter how smooth the effect may be when shown on paper can only result in more or less permanent distortion of the parts. Even though the lip tissue may be scant and the fissure wide and for these reasons the immediate effect of the harelip operation less perfect than might be desired if the cartilaginous nasal structures have been properly restored, and the symmetrical alignment of the lip muscles, particularly the orbicularis oris, probably adjusted later development will have a tendency toward normal lines which will bring about great improvement as the child gets older; whereas, a more perfect immediate result in the case of an infant with imperfect muscular approximation will result in a tendency to continued exaggeration of the defect. In single harelip cases the incision should be begun sufficiently high up in the direction of the nose to give suitable outline to the naris when the parts are brought together. This line should continue downward in such direction as to meet the vermilion border of the prolabium at exactly the right points on each side of the fissure, so that when brought together the lip will be the required length. The knife is carried completely through the lip in a slanting direction with the point toward the fissure on each side. The tissue thus saved will tend to increase the thickness of the lip and prevent depression along the line of approximation. At the prolabial border the resulting flap when turned downward is held with tissue forceps and the knife made to cut toward the fissure close to the skin which is included in the flap but with a sufficient margin of mucous membrane to insure the complete removal of every portion of skin in this situation. One of the most common postoperative defects is caused by the inclusion of a portion of skin in the mucous membrane of the lip. To give additional thickness, both sides of the lip are split longitudinally through the central portion of the raw surface of the freshened border. This is very necessary at the prolabial border of the lip, as it gives additional thickness at this point to preserve the natural form of the lip and frees the mucous membrane sufficiently to avoid a postoperative labial notch. It is not necessary to leave a great excess of tissue at the lip border in order to overcome the effect of scar contraction. With clean work this is really a very inconsiderable factor. A small amount of superabundant tissue should be removed, but this will be very little if the lines of the incisions have been slanted in such manner as to bring most of the excess tissue on the inside of the lip, where it is by all means desirable that it should be to preserve the outward roll of a symmetrical lip when finished.

Sutures.—The first suture is of catgut with a needle at each end passed from the exposed raw surface on each inward through the mucous membrane sufficiently away from the wound border to give good tension resistance and tied on the inside of the lip. Other gut sutures may then be passed with a single needle from the under side of the lip, since the incised tissue surfaces are now in contact. On the skin surface horse-hair sutures are carried through the skin and muscular tissue and out in a similar manner to the other side of the lip. This suture controls hemorrhage from the vessels in that portion of the lip and enables the parts to be brought together for proper estimation in adjustment of the surfaces. A similar suture is placed in the same manner just above the coronary arteries near the prolabial border. A horse-hair suture or a 2000-fine vaselinized linen, as may seem best, is then placed exactly at the border of the skin and prolabium. Perfect approximation at this point is essential. A 2000 fine linen suture is inserted at the opening of the naris. If necessary the floor of the nose is raised by freeing the skin up each

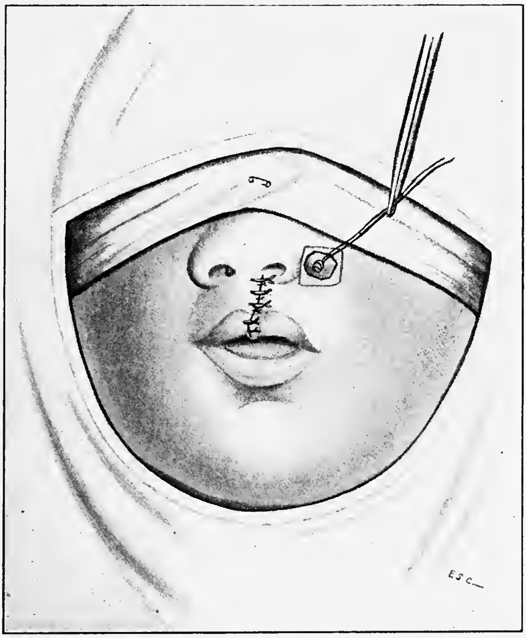


FIG. 344.—Shows diagonal line of approximation. Skin sutures in place.

side of the fissure and held in position by fine sutures extending well up within the naris. In doing this care should be exercised not to make the naris too small and not to obliterate the angle of the curve from the lip to the nose at the opening of the naris. The mucous membrane of the prolabium is carefully approximated and held with horse-hair sutures and coaptation sutures of extremely fine vaselinized linen are then inserted on the skin surface. For this purpose it is advisable to use fine needles designed for suturing arteries, or as the author has found it convenient to do, the finest cambric needles that are made and a 2000-fine linen thread which is made to fit the extremely small eyes of these needles. These are inserted and the skin approximation completed by the aid of a magnifying glass.

Postoperative Control of Dressing.—Undisturbed healing and freedom from suture-scarring, or perhaps complete disaster through separation of the approximated parts, is given by carrying a zinc oxide adhesive plaster strap a little less in width than the length of the nose (in most cases from one-half to three-fourth of an inch) from the cheek on each side across the bridge of the nose, and another similar strap of approximately the same width from the cheeks across the chin and lower lip. These are adjusted in such manner as to make just enough tension to control muscular action in the region of the

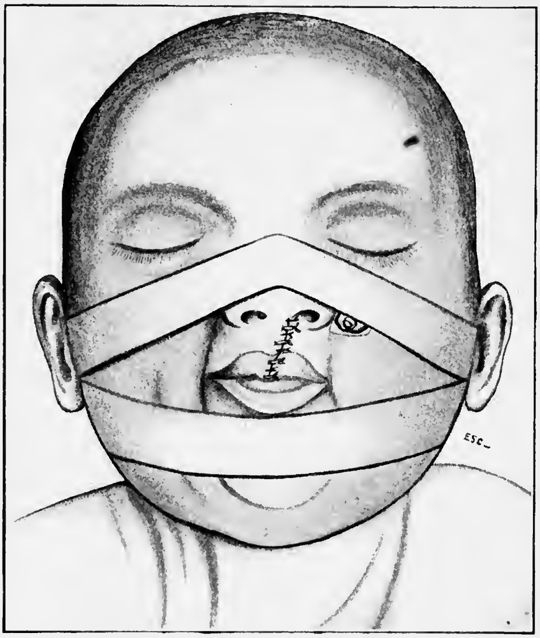


Fig. 345.—The adhesive strip carried from the cheek upon one side across the bridge of the nose to a corresponding point upon the opposite side of the face. Another adhesive strip attached upon the cheek upon one side just below the upper strip, and carried across the chin to a corresponding point upon the opposite cheek. Both of these strips are drawn just tight enough to relieve tension upon the lip sutures, and the lower one is so adjusted as to hold the lips slightly apart to favor respiration after operation. (Author's method.)

upper lip. The lower one is also arranged so that the lower lip is turned slightly downward, thus insuring that the mouth may be kept open during the period of reaction from the operation (Fig. 345). These straps are left undisturbed until the sutures are removed. A piece of lightly fluffed gauze is laid across the upper lip and attached upon the cheeks by short adhesive strips. This can be changed by the nurse without difficulty whenever it becomes soiled and the wound surface is thus easily accessible for observation and postoperative treatment if necessary.

Relief of Tension.—When the fissure is unusually wide and the cartilaginous wing of the nose extremely flat and spread out there is

Fig. 346.—Infant with very wide fissure through lip and hard and soft palates, also marked nasal deformity.

Fig. 347.—Same child as shown in Fig. 346 at four years of age, after the lip and palate operations have been completed. The final operation was performed when she was two years old. Tendency toward correct development may be noted.

Fig. 348.—Infant with harelip and complete cleft palate. The nose has been partially straightened and the fissures made narrower by wearing an adhesive strip as described.

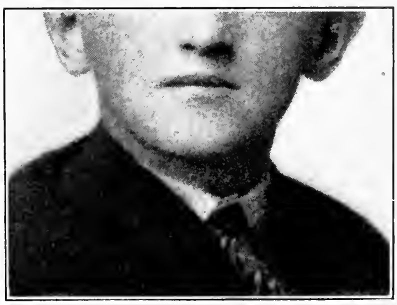


Fig. 349.—Same child at six years of age. The lip was closed at about two months, the hard palate between five and six months, and the soft palate at two and a half years. The symmetrical development of face, nose, mouth and jaws at six years old seems tc prove that this would not have been possible had any growing structures been seriously damaged in the course of the early operations.

always marked deflection of the nasal septum as well as the triangular cartilage. In such cases the lip should be set free by incisions through the gingivolabial fold of the mucous membrane carried close to the bone and high enough up to completely free the ala on the affected side, and also to release the most active fibers of the antagonizing muscles. On the opposite side the lip attachments to the premaxilla should be set free in the same manner, and in extreme cases the knife carried backward to sever the anterior end of the nasal septum close to its maxillary attachment. The fixation of the silkworm-gut splint suture which has previously been placed may then be depended upon to bring about the necessary readjustment of these parts.

Double Harelip.—The general characteristics of these cases are much the same as in single harelip and yet there are important individual differences as represented by the extent of the deformity. In some instances the detached premaxilla is comparatively large and the elongation of the nasal septum and vomer not so great as to cause extensive protrusion of the premaxillary structures. This permits the overlying lip tissue in the region of the philtrum to be sufficiently free and well nourished to make closure of the fissure much more simple than in other cases with marked protrusion of the premaxilla, extensive deformity of the septal structures, and so little tissue forming the philtrum of the lip as to make any attempt to make the necessary reconstruction a matter of great difficulty. In dealing with this exaggerated form of double harelip cases there is always a strong temptation to adopt the old type of operation in which the lip fissures are closed by freshening the borders of this central portion of the lip so as to make it form a three-sided square and then to carry across from the lip tissue on each, outside of the fissure flaps to be brought together and attached to the squared edge of the philtrum, in such manner as to make an artificial prolabium (Fig. 350), but no matter how this may be done the result as shown in Figs. 365, 367, and 380 is inevitable.

Contraction of the transverse scar tissue thus formed at the prolabial border is invariably such as to draw it inward and downward. The lip thus becomes unusually long and in some cases almost hopelessly deformed. It requires infinite patience and some courage to take the position that it is better to treat this single segment of lip tissue, no matter how small it may be, in the same way that one would treat a larger one. Even though the immediate effect may not be encouraging, once the lip muscles on each side are attached to the central division the physiological activity will tend to bring the parts into their normal relation and cause growth of the deficient lip tissue. In the course of time this may be depended upon to grow into a lip surface of sufficient size to permit its later readjustment in such manner as to give nasal, facial, and labial perfection that could not be secured in any other way (Figs. 346 to 349).

Treatment of the Nasal Septum and Vomer.—Inasmuch as there is not only distortion of these structures but a superabundant growth as well, these conditions must be considered in overcoming the deformity. No tissue should be wasted by excision that can possibly be saved.

The removal of a V-shaped section from the lower border of the nasal septum as is sometimes advocated, gives the mouth a rabbit-shaped appearance that becomes very unsightly as the patient grows older. In newly born children the author has found it advisable to take advantage of the double development of the nasal septum, the divisions of which may easily be separated by passing a strong, broad knife in an anteroposterior direction between them. This makes it possible to spread them apart as the premaxilla is pressed back into position and not only prevents loss of tissue but helps to reduce the size of the opening in the palate as the intervening space fills in. In

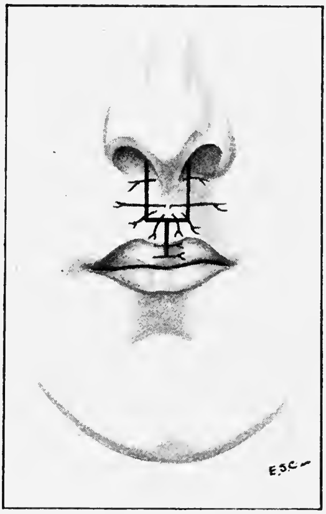


Fig. 350.—Illustration of method of performing double harelip operation which has been widely employed by surgeons but which in the author's experience invariably leads to deformities such as shown in Figs. 365 and 367. It should be avoided by every possible expedient.

older children when bone has formed it sometimes becomes necessary to make a diagonal cut through the septal structures to allow them to slide past each other when the premaxilla is brought into position. The supporting splint tension suture is passed from the skin surface just outside of the angle of the cartilaginous wings of the nose on each side through the nasal septum so that when the silver plates and shot are adjusted the parts are held in proper relation (Fig. 350).

Each lip fissure is closed separately as by two simultaneous single harelip operations (Figs. 351 and 352). In some cases the premaxilla is almost entirely absent and there is practically no lip tissue in the region of the philtrum. Under such circumstances it may be absolutely necessary to extend tissue from the outside lip borders across to the central line but such conditions are very rare. With care to avoid traumatic injury and by not making the sutures tight enough to cut off the circulation, the necessary two rows of sutures may be success-

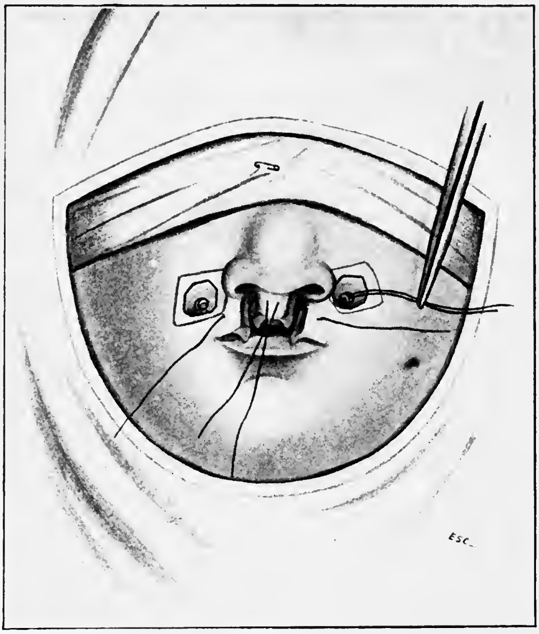


Fig. 351.—Author's method of double harelip operation. Fissure borders prepared for the sutures. First control suture in place.

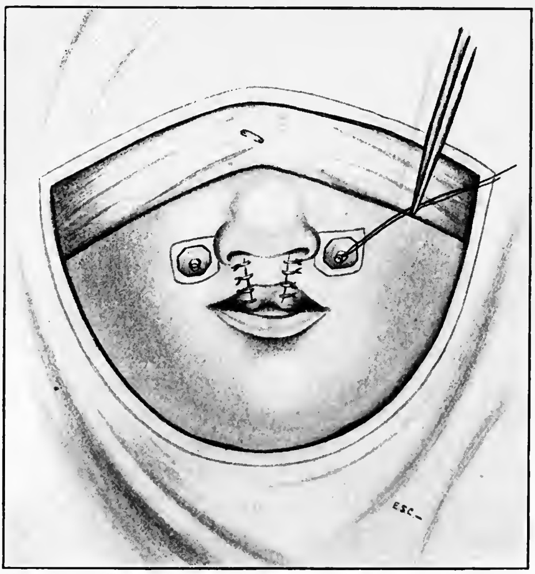


Fig. 352.—Author's method of double harelip operation. The operation completed and skin suture in place.

fully passed through quite small portions of the lip philtrum and good immediate results can be accomplished with the assurance that

Fig. 353.—Child with double harelip and a cleft palate that has previously been operated without success.

future development will bring a continued improvement in cosmetic effect. Figs. 353 to 372 show the results of such treatment.

After-treatment.—The less the wound is disturbed in the course of after-treatment the better. Because of the likelihood of infection from the nose and mouth it is not advisable to use a dressing which will

Fig. 354.—Same child as shown in Fig. 353, after the lip has been corrected. This illustrates in slight degree the difficulty of overcoming the appearance of flatness of the anterior part of the mouth when the underlying bone structures have been compressed in an attempt to close the palate fissure.

prevent its constant observation. If interference appears to be necessary, touching with applicators dipped in dioxogen serves to give the necessary cleanliness after which alcohol applied in the same manner dries and cleanses without disadvantage.

The Correction of Postoperative Lip and Other Associated Nasal Defects.—There is almost no limit to the possibilities of improvement that may be made by the correction of the lips and noses of the unfortunate

Fig. 355.—Infant with double harelip.

Fig. 356.—Same child after operation.

victims of early operation. Bearing in mind the fact that these defects are chiefly due to three causes corrective efforts must be directed in such manner as to overcome them to the best advantage.

The first type of these cases is represented by the individuals whose features have become distorted through the destruction of some essential developmental structure.

Fig. 357. — Characteristic scar with notch following harelip operation.

Fig. 358.—Same young man as shown in Fig 357 after correction of the lip defect and closure of a wide fissure through both hard and soft palates.

The second by those who have suffered increase or at least continuation of the original nasal and facial distortion through failure to bring properly into play the corrective influences that would have been exerted if there had been proper readjustment of these features in infancy. In both these types there will be usually found much unsightly scar tissue (Fig. 392).

Fig. 359.—Child, aged two and one-half years. One-half of lip and palate almost totally destroyed as a result of attempted closure of lip and palate at the same time. Forcible compression of the sides of the palate was attempted in early infancy.

Fig. 360.—The result of closure of the lip for the little girl shown in Fig. 359.

Fig. 361

Fig. 362

Fig. 361.—Front view of boy, aged four years, for whom the operation of forcibly closing his palate fissure and attempting to hold the parts with wire and lead plates was performed in early infancy. The lip was closed at the same operation. Both lip and palate sloughed out except for a small bridge of tissue which fixed the maxillary bones as placed. Not only did he lose almost the entire lip upon one side, but the deformed shape of his face, which is characteristic of the result of these operations, remains permanently, as is plainly shown in the illustration.

Fig. 362.—Same boy as shown in Fig. 361, several years after operation.

The third form of postoperative deformity in these cases is due to an increase in size as well as deformity of the immediately associated parts. This is usually noticeable in the cartilages at the end of the nose, more especially the cartilago alaris major and the lateral nasal car-

FIG. 363.—Child, aged three years. Lip nearly half lost by operation upon both lip and palate at the same time in early infancy.

FIG. 364.—Same child as shown in Fig. 363 after closure of the lip fissure. Brown's O. D. and M.

FIG. 365. — Front view of boy whose palate was closed in early infancy with what appeared to be a successful operation. The result at seven years old may be seen. Complete stenosis of left naris, right side of nose almost absolutely useless for breathing purposes, although probe can be passed through. Disproportion between the upper and lower parts of the face and head due to arrest of development. Voice shrill, high, and by no means perfect in pronunciation.

FIG. 366.—Front view of same boy as shown in Fig. 365 after operation for the correction of his lip and facial defects.

tilage. The operation for correction of this defects is shown in Figs. 373 and 374.

FIG. 367.—A young man whose lip was operated upon in early infancy without due consideration for developmental principles.

FIG. 368.—The same individual shown in Fig. 367 after operation upon the lip and readjustment of the deformed parts.

Direction of the Line of Scar.—A diagonal line of approximation not only gives the advantage of a slanting scar but also tends to prevent the intensification of the defect when the lip is under tension as

FIG. 369.—Boy, aged fourteen years, with harelip and cleft palate. Shows the increase of the deformity that occurs when such cases are neglected until advanced stage.

FIG. 370.—The same boy as in Fig. 369 after both lip and palate have been closed.

in smiling. Not infrequently a lip that looks well when the parts are at rest will show a very unsightly scar when the individual laughs.

In boys a mark well to one side of the central line can readily be covered by a mustache which would show a noticeable defect if part-

Fig. 371.—Infant with double harelip and cleft palate. The history of this case before coming to me shows that a few days after birth an attempt was made to close the palate fissure by the use of silver wire and lead plates. The wires sloughed out and there was a general infection, as a result of which the child was in a very critical state for several weeks before recovery.

Fig. 372. — The same baby after I have closed the lip and hard palates. It will be seen that it was impossible to get as perfect a result as might have been obtained had the first operation not been performed.

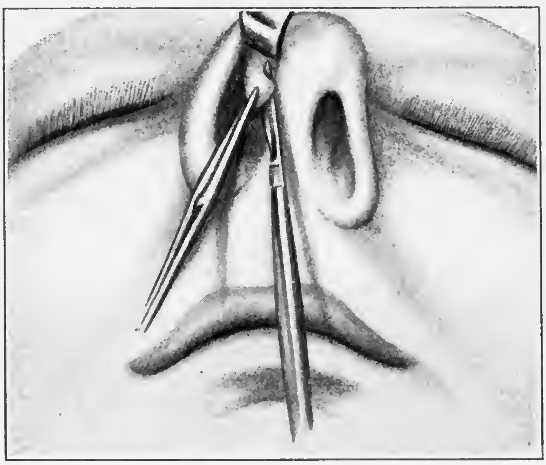


Fig. 373.—Shows the method of removing the excessive tissue from the cartilaginous end of the nose in such cases without external incisions, thus avoiding scar disfigurement.

ing in the central line were interfered with as would be the case if the scar were close to the situation.

In girls, effort should be made to bring this line as close to the median line of the lip as may be practicable because the usual depression through the central portion of the philtrum or the columns of the

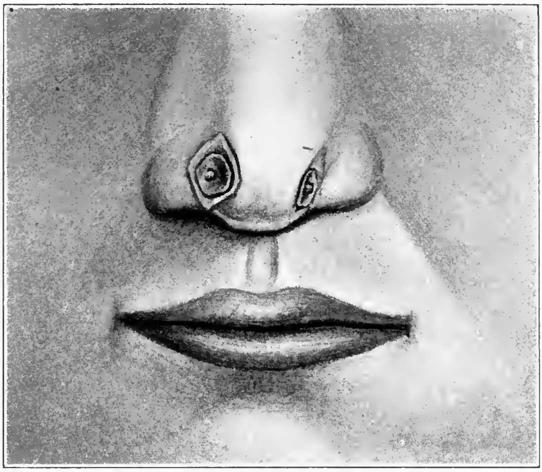


Fig. 374—Fixation suture in place for operation illustrated in Fig. 373.

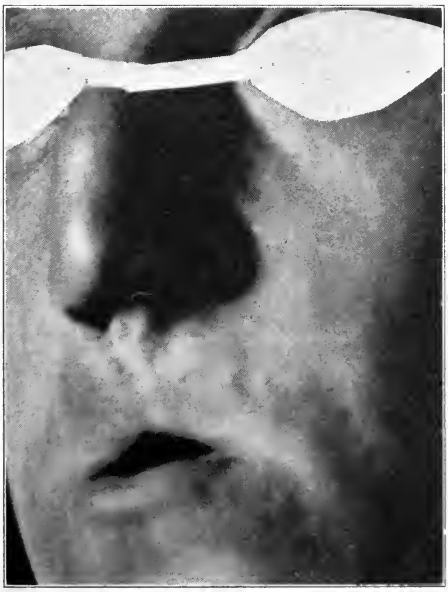


Fig. 375.—A man, aged twenty-five years, who had had many previous operations for harelip and cleft palate.

lip on each side of this central depression may be simulated to such an extent as to almost completely hide the original trouble. The same rules should be kept in mind in the adjustment of the lines of approximation in double harelip operations, without endangering the immediate result too much by efforts in this direction.

FIG. 376.—Same young man after excision of scar, readjustment of prolabial border, correction of the form of the alar cartilages and the removal of the flatness on right side of cartilaginous tip of nose by the insertion of a rib cartilage transplant through an incision made just inside the skin border at the outer anterior part of the naris. Restoration of the outlines may be noted.

CLEFT PALATE.

The *types* of cleft palate in form and character from a bifid uvula with both hard and soft palates otherwise intact, to fissures which divide the velum palati or the bony palate partially or completely, and continue entirely through the alveolar ridge and the lip. Such clefts may be confined to either of the two palatal divisions without the other being affected, and they may be single or, if associated with double harelip, be divided through the central line by the nasal septum and the vomer in such manner as to have the appearance of a double cleft palate.

The Non-surgical Treatment of Palatal Fissures.—The non-surgical treatment of palatal fissures by the use of obturators in the form of plates with artificial vela capable of more or less movement in speech is usually unsatisfactory. Such appliances have sometimes been brought to a very high degree of perfection and there have been notable examples of individuals who have acquired almost perfect speech through the assistance of these mechanical aids. Nevertheless a palate fissure closed by natural tissue with the muscles properly approximated is in all respects more advantageous. This is not only true with regard to speech, but also because tissue restoration favors conditions which pertain to improved local as well as general health and cleanliness. A palate surgically restored gives a feeling of satisfaction to the affected individual that an artificial substitute never can approximate.

The Standard of Staphylorrhaphy.—The following principles should govern the selection of a method for the surgical treatment of cleft palate.[1]

1. A deformity should not be corrected by surgical or other forcible means if such defect may be made to correct itself in the natural course of development, or if its presence does not interfere with perfect function of the palate.
2. No structure should be destroyed that may be required for the perfection of future developmental processes.
3. No tissue should ever be misplaced or otherwise altered in such manner as to impair its future functional usefulness.
4. The reparative possibilities of tissue in flap formation should not be overtaxed in an endeavor to close completely at one operation the palate fissure of cases in which this is inadvisable.

The *several distinct operative methods* in performing staphylorrhaphy are:

1. *Compression* (forcing the sides of the bony palate in early infancy as advocated by Garretson, Brophy and others); (2) *flap-reversing operations* (Lane, Davies-Colley); (3) *bone and mucoperiosteum flap formation* (Ferguson). (4) *Median mucoperiosteal flap-sliding operations* (von Langenbeck-Warren).

Compression Method.—The most widely known operation of this type as perfected by Dr. T. W. Brophy of Chicago, is performed in early infancy and before the lip fissure is closed. Silk ligatures in special needles are carried through the upper jaw above the bony palate on each side. By the aid of the loops thus formed, silver wire, 18 to 20 (American gauge), is carried completely through at both the anterior and posterior portions of the mouth. These wires are threaded through holes in lead plates of suitable size and shape in such manner as to cause compression when the wires are twisted and the maxillæ forced together to close the anterior portion of the cleft, the borders of which are duly freshened and the posterior portion of the palate closed with sutures (Fig. 366).[2] High mortality is a serious objection to this operation. While it is true that newly born infants withstand the shock of operation in some respects better than older children, they are nevertheless highly susceptible to the effect of continued irritation, infection and difficulties in taking nourishment. These disadvantages are necessarily attendant upon the retention of wires, lead plates and similar substances in the jaws, nose and mouth. There is good reason to believe that if the death-rate under this method as employed by surgeons during past years could be shown it would be appalling. It

[1] Lancet, September 12, 1914. Surg., Gynec. and Obst., vol. xx, No. 1.
[2] Berry and Legg: Harelip and Cleft Palate.

also endangers the developmental processes upon which the future form of the nares, the palate, the upper dental arch and the face depend. Compression of this character cannot fail to cause an unnecessary degree of deflection of the nasal septum and marked narrowing

Fig. 377.—Boy, aged nine years. An attempt was made to close the palate fissure by compression in early infancy. This failed, and many subsequent palate operations also failed as a result of the first one. I have recently closed the remaining palate opening, but the deformity will be difficult to overcome.

Fig. 378.—Girl, aged six years. An operation to close the palate fissure by compression and wiring in early infancy failed. Several later attempts by other operators also failed. As a result of this early treatment the entire upper palatal arch is less than the size of a twenty-five cent piece in diameter, and all the teeth but four due at this age were destroyed by the wires.

Fig. 379.—Profile view of the same boy as in Fig. 361. The malposition of the maxillæ and consequent deformity of the nose which resulted from forcing these bones together to close the palate fissure in early infancy are markedly apparent.

of the nares. Wires employed for retention purposes when passed through the upper maxillæ of an infant inevitably destroy from one to four or more of the developing tooth germs therefore these teeth do not erupt.

The claim that in passing a needle through the upper maxillary bones of infants, the developing teeth may be avoided by sense of touch when the point of the needle meets unerupted teeth, is misleading. This may be true to some extent in so far as the calcified crowns of the teeth are concerned, but the wide open root portion of the partly developed tooth presents no such hard surface to indicate when the needle may

Fig. 380.—Boy, aged seven years. Shows the characteristic facial appearance after the removal of the intermaxillary bone in operation for double harelip.

Fig. 381.—Side view of boy shown in Fig. 366, also Fig. 380 after operation for the restoration of more natural lines in profile.

Fig. 382.—Boy, aged nine years. Previous history shows that an operation was performed in early infancy in which an endeavor was made to close the palate by the use of wires through the jaws and lead retaining plates. This failed disastrously, and was followed by four other operations with only partial success. The difficulties were enormously increased by the effect of the early infancy operation.

Fig. 383.—Same boy as shown in Fig. 382, after lip and nose have been reconstructed and the palate fissure closed by two operations. It was necessary for me to readjust the malposed parts and partly close the palate fissure at the first operation, and to complete the closure one year later. Since this picture was taken he has been for several years under treatment by his dentist, who has been endeavoring to bring the malposed teeth into proper alignment.

be passing through its really vital portion (Fig. 377). Without the eruption of the full number of teeth there cannot be a normally shaped dental arch or palatal vault. It is obvious, then, that with intranasal deformity there must be a tendency to nasal disease, that with arrested maxillary development there cannot be a symmetrical face, and with a contracted palatal vault, as well as an irregular dental arch, the best speech function is impossible. Figs. 377 to 383 show the result of this treatment in these cases and many similar examples might be shown if necessary to prove that such effects are not uncommon.

Clamps.—Various forms of metal clamps for reducing palate fissures have been recommended. The same objections which pertain to other methods of maxillary compression in cleft palate cases apply to the effect of their appliance also. Dr. Ulrich of Copenhagen has devised a clamp which grips the jaws with arms that may be gradually tightened by the adjustment of nut and screw. In this relation it is sufficient to say that the employment of assistance of this character is unnecessary for successful palate closure no matter how wide the fissure may be. The author's adjustable fissure-narrowing splint attached to the teeth on each side, and tightened with a screw, may be useful in very wide fissure cases. Cutting and partially fracturing the maxillary bones on each side prevents narrowing the nares when pressure is applied. Such assistance is very seldom if ever necessary.

Transplantation of Tissue to Cover Palate Openings.—Of passing interest but no practical value, except in cases in which previous operations have destroyed a great portion of the original tissues, are the reports of attempts to carry flaps from the lips, cheeks, chin and other extrapalatal surfaces and attach them in the mouth to cover palatal fissures. Fixation of a finger in the palate and other experiments of like nature have also been reported.

Reversal of Mucoperiosteum in Flap Formation.—In the Lane operation an incision is made along the alveolar ridge on one side of the mouth in infant cases, or close to the gingival borders of the teeth on one side for older patients. The mucoperiosteum on that side of the palate is separated from the bone surface in such manner as to leave its attachment along the border of the fissure unimpaired, thus forming a flap which can be turned over and secured underneath the periosteum on the opposite side when freed by making an incision along the inner border of the fissure (Figs. 384 and 385). When the parts are sutured in this position the mucous membrane of the reversed flap is toward the nose and its raw periosteum on the oral surface. Sir Arbuthnot Lane of London, performs this operation on infants in a wonderfully skilful manner. There is practically no tension and the approximation of the thick raw surfaces thus secured by the use of his special needle-holder and very fine needles would be very advantageous were it not for certain definite reasons which appear to make every such operation inadvisable.

Assuming that complete union may have taken place and the raw exposed surface of the reversed flap completely healed the transposition of tissue in this manner must militate against perfection of form at the posterior portion of the soft palate. This bears an important relation to speech function. It is also safe to assume that whether bone might or might not form from periosteum that is kept in its normal situation, as in other operations, it certainly cannot do so with osteogenetic activities destroyed by this transposition.

The author has seen large numbers of persons who had no visible palate fissures and yet who had all the characteristic cleft palate defects because the palate bone formation was imperfect. It is therefore not sufficient for speech purposes to secure a mere covering of soft tissue across palate fissures for both form and underlying support are important factors. Murray, Berry and others criticise the Lane operation by calling attention to the fact that there do not appear to be many examples of patients who were operated upon in infancy according to Lane's method who have acquired good speech in later life. Another serious objection is that if sloughing were to take place with the palate tissue treated in this manner the loss would necessarily be such as to injure it almost beyond repair.

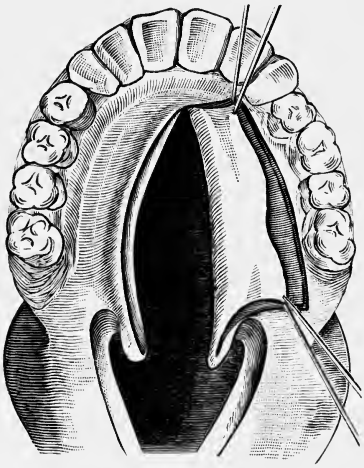


Fig. 384.—Lane's method of removing mucoperiosteal flap from hard and soft palate upon one side of the cleft, and tucking the edge of this flap under the mucosa through a slit upon the opposite side of the cleft. (After Eastman.)

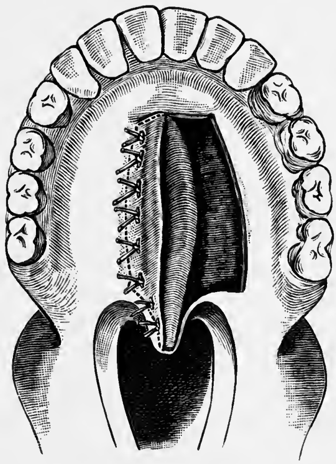


Fig. 385.—Edge of flap tucked under slip upon opposite side of cleft and sutured. (After Eastman.)

The Davies-Colley Operation.—Follows the same idea as that of Lane. According to this method a mucoperiosteal flap upon one side is reversed, a flap that is free at the anterior end with a broad pedicle at the posterior portion of the palate is carried over and laid on top of the raw surface of the reversed flap (Fig. 386). This method also tends to relieve tension and does give a certain proportion of the thick raw surface which favors healing, but it is open to the same objections previously outlined in connection with the Lane Operation. Finally it may be said that none of these methods are necessary because good results can be obtained by operations which do not entail these objectionable features.

Method of Including Bone with Mucoperiosteum in Flap Formation.—This operation which was devised by Ferguson, advocated and practiced for years by Dr. J. Ewing Mears of Philadelphia, and then allowed to become almost obsolete, has comparatively recently been improved by Roe of Philadelphia with very good results. Incisions are made along the borders of the teeth on each side down to the bone surfaces. With a chisel the bone structures on each side of the palate

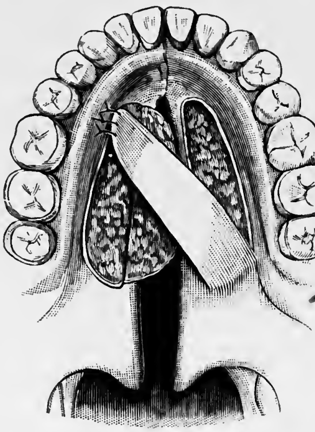


Fig. 386.—Davies-Colley operation for cleft of the hard palate. Flaps in position. (After Treves.)

are cut through in a slanting direction toward the central line. "E" banjo wire strings used for sutures are passed into holes made through the bone on each side of the fissure. The anterior bony attachments are freed by forcing the parts together from each side, and the wire sutures are tied in such manner as to make a complete approximation in the central line. The soft palate is then closed (Fig. 387). The

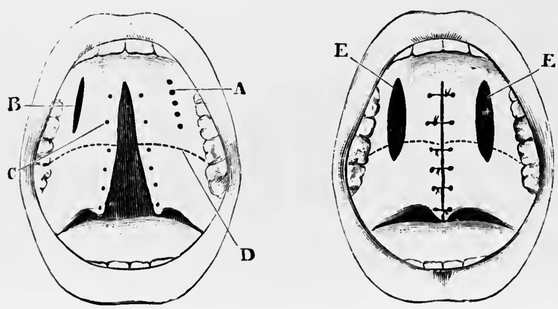


Fig. 387.—Fissures of the hard palate: *A*, preliminary punctures with awl to give line for chisel; *B*, incision through bone completed by chisel; *C*, holes bored through hard and soft palates for sutures; *D*, junction of hard and soft palate; *E*, lateral openings subsequently filled up by granulation. (Bryant.)

promise of securing actual bone formation in symmetrical outline at the posterior portion of the hard palate that this method gives is one that merits its due consideration. Roe seems to have had little difficulty with necrosis of the bone included in the flaps but it must be kept in mind that if such necrosis did occur through extensive sloughing there would be danger of completely ruining the palate for future operative purposes. The editor has had many good results with his own adaptation of these methods.

Median Flap Sliding Operation.—Although Lemonier, a French dentist, in 1764 originally proposed and took the first steps toward surgical closure of a cleft in the soft palate, and in 1819 Roux, of Paris, performed such an operation, Warren, of Boston, in 1820, seems to have been the first one to surgically close a cleft palate with sufficient success to warrant continuance of the method. To von Langenbeck is due the credit of having suggested and successfully practiced closing of fissures of the hard palate by making incisions upon each side, raising the mucoperiosteum and suturing it through the central line of the palate. All of the urano-staphylorrhaphy methods of this type are based upon the principles of this operation. The author has secured his best results by modifying and adapting the principles of the von Langenbeck-Warren operation to the formulation of a system whereby one operative step leads gradually to the next from the very earliest period of infancy. All the necessary operations are completed before the child is old enough to talk and thus the acquirement of wrong speech habits is avoided. In this way also the surgical difficulties of each successive operation may be reduced without unnecessary destruction of important developmental structures, and with the best possible alignment of the osseous and muscular parts to the end that future growth and functional opportunities may be favored.

Operative Steps According to the Author's Methods.—Age of Operation.—In the treatment of infants with complete fissure through lip and palate it is advisable to close the anterior portion of the cleft including as much of the hard palate as possible, as soon as the child may have fully recovered from the effect of the lip operation (Fig. 388). Usually this means at approximately four to six months of age. The velum palati is closed one year later with less danger to the child and more certainty of securing a perfect result than if the entire palate were closed throughout at one operation (Fig. 389). By having the palate so completed before the child begins to talk there is less likelihood of the acquirement of wrong speech habits which are sometimes difficult to overcome in later life.

In cases of older children and adults, both the uranoplasty and staphylorrhaphy may be simultaneously performed. When the cleft does not extend through the alveolar portion of the jaw the time of operation should be governed by the circumstances of the case and a complete closure of the cleft effected without the two-stage method of operation.

Control of Hemorrhage.—With the raw surfaces of palatal flaps exposed in the nasal region and the other necessary incisions there is much opportunity for blood oozing if abnormal conditions be encountered. It is therefore an advisable precaution to have the coagulability of the blood tested in addition to the usual preoperative blood examination.

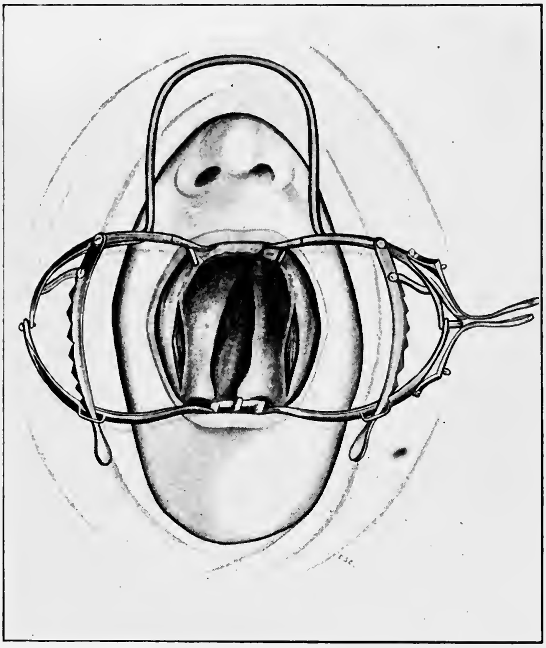


FIG. 388.—The author's method of palate operation for infants. The attachments slipped through the arm of the modified gag clasp the anterior part of the alveolar ridge as shown. The incisions as used for these cases are as described.

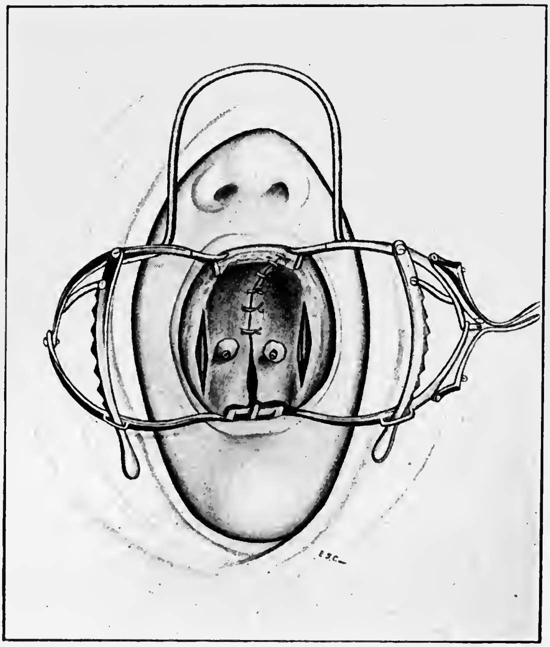


FIG. 389.—The hard palate closed and the tissue of soft palate brought close together but not sutured as advocated for infants when the hard palate is cleared first, and the soft palate one year later as described in the text.

Fortunately air will pass freely through lightly packed gauze when blood will not, and taking advantage of this, a narrow strip of gauze, folded as for gauze drainage, is packed lightly into the pharynx with one end projecting out at the corner of the mouth for safety. This in the author's opinion is a more suitable method for palate operations than that of passing a tube into the trachea and firmly packing gauze around it in the pharynx. The anesthetic tube is thus left entirely in view and there is less danger of the condensation of the anesthetic allowing it to be blown directly into the bronchi and lungs. There is also an advantage in having the faucial arches left entirely free from fixation or distortion by firmly packed gauze. Every endeavor should be made to avoid the larger vessels as much as possible to reduce hemorrhage and insure better flap nourishment.

Paring the Fissure Borders.—Notwithstanding the following very timely suggestions by Berry[1] who says, "If the edges are pared before the detachment of the soft tissues from the bones, they are exposed to injury and infection from sponges and instruments during the subsequent stages," the author believes that the counteracting influences to which Berry also calls attention when he asserts that the "only objection to late paring is that it is a little more difficult to cut neatly along the edge of a loose fold" is more important than any disadvantage which may be suffered through the impaired freshness of the exposed tissue border.

Position of the Patient.—The position of the patient is the same as described for harelip operations. With the shoulders raised sufficiently to tip the head backward all the advantages of the Rose position with the head hanging over the end of the table are secured. It has always seemed to the author that he could approximate the palate borders in more natural alignment when he faced the operative field directly than he could if viewing it in reverse position as is usually done by those who favor the Rose position. This, however, is a matter of personal choice and not of vital importance.

Control of the Field of Operation.—It is impossible to perform suture and tissue adjustment in the region of the mouth and pharynx with sufficient accuracy unless the field of vision be clearly in view, with the jaws and tongue held firmly in suitable position and hemorrhage as well as excessive mucous secretions under control. These considerations must be kept in mind in selecting a mouth gag. The author's mouth gags shown in Figs. 390 and 391 are modifications of the Whitehead gag whereby the view of the anterior part of the mouth is unobstructed and steadiness secured by the curved arms which are fixed inside the teeth.

Preparation of the Field of Operation.—Whenever possible the nose should be irrigated with saline solution, glycothymoline or some similar preparation for as long a period of time before operation as may be practicable. Even a few hours of this treatment may be

[1] Harelip and Cleft Palate. (Berry and Legg.) Chapter VII, p. 197.

helpful. Diseased conditions of the teeth also require preparatory treatment. The face, mouth, teeth and gums are cleansed, scrubbed and treated with alcohol and iodine. The borders of the fissure are touched with applicators dipped in adrenalin to facilitate the accurate paring of the fissure borders by temporarily checking hemorrhage.

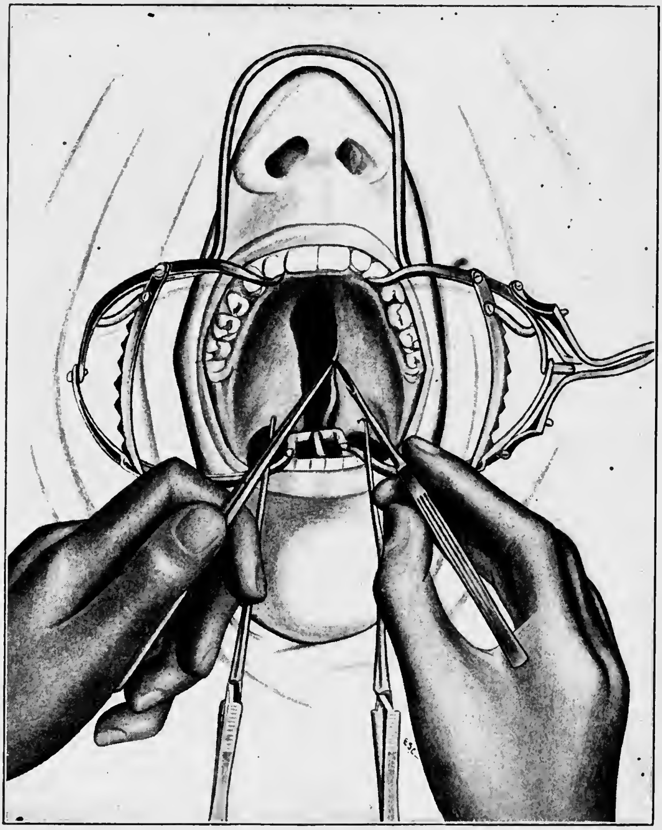


FIG. 390.—The author's self-retaining fixation forceps attached to hold the soft palate taut to favor perfect operative work upon the fissure border are sometimes advantageous, but in ordinary cases such assistance is not required. A mosquito forceps holds the palate border sufficiently taut and is less likely to damage the tissue. Paring the border of the fissure. The author believes that a palate border pared and split is more dependable for a secure line of union than one split and not pared.

By splitting the border to increase its thickness at the last possible moment before the sutures are inserted, even the possibility of such disadvantage is overcome. Some writers maintain that it is unnecessary to pare the borders of the palate, because splitting them is sufficient, and in this way a saving of tissue is effected. In this regard it is important to consider that the differences in the character of the tissue at the borders of palate fissures are often very great, especially when previous operations have been performed which were followed by sloughing. It is therefore quite certain that what might be a sufficient preparation to secure union in one case would be absolutely insufficient in another. There is, moreover, a considerable alteration in the line of tissue approximation during the contractions which are sometimes associated with the healing of the parts. For this reason it is absolutely necessary to have as thick a border of raw surface along the whole line of flap approximation as can possibly be secured.

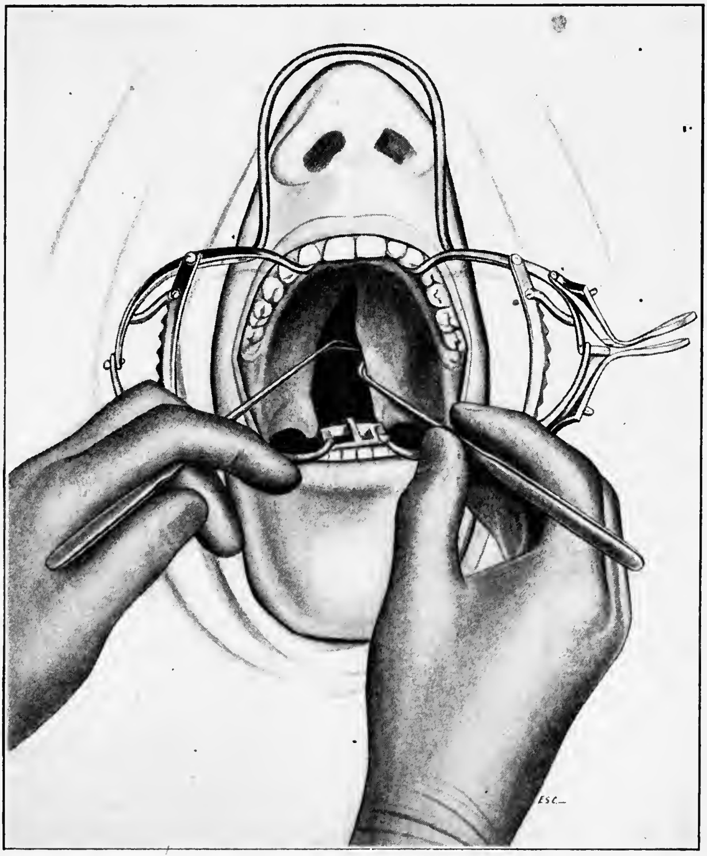


FIG. 391.—Mucoperiosteum raised while the author's knife, safe on the upper side and bent to a suitable angle, is used to sever the tissue attachments at the posterior border of the hard palate.

It is also important that the line of approximation may be perfectly in accord with the natural formation of the tissue along the borders of the fissure. If tension cannot be overcome sufficiently to make the tissue loss in the course of careful border paring an inconsiderable factor, then the suture tension will almost invariably be too great in any event. The author believes that a thin strip of tissue should be carefully removed along the entire outline of the fissure border, particularly in the region of the soft palate and as far forward as it may be freely movable. In the anterior portion of the cleft this is not so important, and it is sometimes unnecessary. Every effort should be made to follow the line of the nearest approximation of the sides of the fissure when the parts are at rest.

This will be the true line of natural approximation, and therefore the one least likely to suffer from the effect of antagonizing muscular action during the healing process. The thickness of the paring should include the mucous membrane and sufficient underlying tissue to give a definite raw surface. Just before the sutures are tied, the freshened borders are touched lightly with a knife to split them and allow the eversion of tissue to present a perfectly fresh raw surface. The thicker and fresher this may be the greater the certainty of immediate firm union.

Anesthesia.—The author's experience in operations upon palates under local anesthetics and with analgesia induced by the administration of nitrous oxide gas, as well as the more profound states induced in the same manner, has been such as to lead him to believe that the administration of ether, when heated, vaporized, and blown into the mouth, is in many respects the most desirable anesthetic for these cases. When administered by Gwathmey's or some similar apparatus, this agent is very satisfactory, and much safer than chloroform because there is less immediate danger and much less likelihood of the postoperative effects of chloroform poisoning. Although there may be freedom from actual pain when local anesthesia or a state of analgesia is induced there is much to cause apprehension on the part of the patient as the operator proceeds and sometimes this gives rise to unnecessary shock when patients are conscious during the operation. The author gives the usual preliminary hypodermic injection of $\frac{1}{6}$ gr. morphin and $\frac{1}{120}$ gr. of atropin about thirty minutes before the operation is begun for adult patients and less for children.

Preparation of Mucoperiosteal Flaps.—A rectangular knife is carried completely around the border of the bony palate fissure, this makes it possible to insert the mucoperiosteal elevator between the periosteum and the bone surface. This incision should be as clean-cut as possible in order to give a favorable outline when the flaps are raised. The author's periosteal elevators are made in different sizes and with different angles. This is advantageous, because the slope of the sides of fissured palates varies very greatly and for this reason the traumatic injury which the periosteum may suffer will be governed by the suitability of the form of the instrument to the angle of the palate walls. Occasionally the form of the palate surfaces may be such as to make it advisable to supplement the efforts to elevate the mucoperiosteum from the fissure border by passing a straight elevator through an incision close to the lingual sides of the teeth to detach the tissue from above downward. The fibrous aponeurosis which binds the velum to the palate bones, and also its nasopharyngeal attachments, are severed to force them up and permit unrestricted coaptation of the parts and also to prevent antagonistic muscular action. For this purpose the author has right and left knives safe on one side and bent at an obtuse angle to facilitate cutting in an upward direction at a favorable angle to follow the posterior border of the hard palate without injury to the underlying tissues. Curved scissors, as recommended by Berry, may be used for the same purpose (Fig. 392)

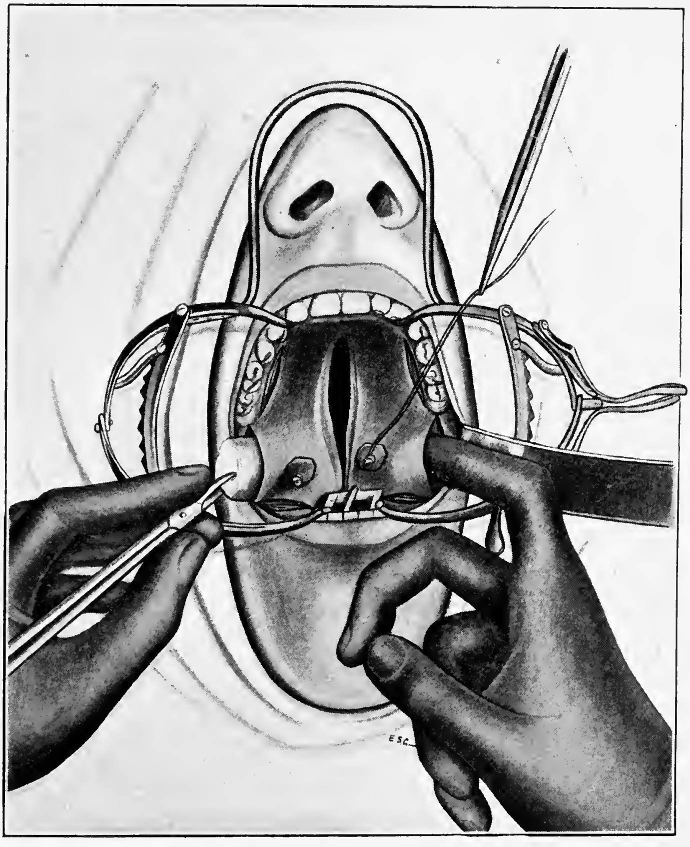


Fig. 392.—Silkworm gut tension suture in place with silver plate slipped over its free end down to the palate surface and followed by four lead shot. Method of freeing the soft palate tissue, and forcing it toward the center through the lateral incisions. Pad inserted as used to control hemorrhage when necessary. A gauze drain may also be used to pack this opening.

Sutures.—Silk, linen, silkworm gut, horse-hair and steel, silver and aluminum-bronze wires have all been tried with more or less advantage and disadvantage. The objections to any suture material which through absorption of the oral secretions may itself become a source of infection are important. Wire sutures are difficult to adjust with nice approximation. Even though very carefully inserted they are likely to traumatize, and cut the palate tissues.

The author uses formalized pyotanin catgut, supplemented, as occasion may require, by horse-hair sutures inserted with a very fine needle after the palate has been closed to give more perfect coaptation of the mucous membrane at points where retraction seems to make this additional safeguard necessary. For many years he used a small aluminum bronze-wire tension suture inserted through the muscles of the soft palate, supplemented by silver plates at each end secured

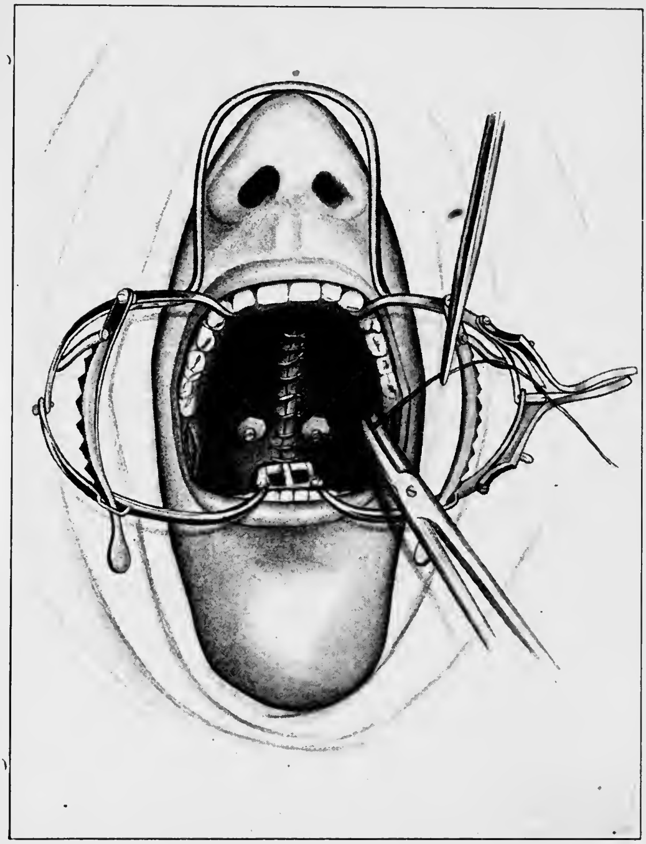


FIG. 393.—Fissure borders coapted with pyoktanin gut sutures. Wire tension sutures in place and the last shot being compressed to hold the plates. The author seldom finds it necessary to use more than one wire retention suture. Occasionally the second one is required.

by lead shot clamped upon the wire. This relieved the immediate strain on the coaptation sutures and later gave resistance to the pernicious activity of reunited muscular attachments. Recently, however, he has used with much success the simpler plan of substituting silk worm gut for the wire. It serves the same purpose, its insertion requires less skill in avoidance of traumatic injury, and if through accident it should become detached and swallowed, a silk worm suture would be less troublesome than wire (Fig. 393).

This suture is placed first and tightened just enough to hold the parts of the soft palate sufficiently close together to facilitate placing the other sutures without undue tissue strain or the traumatism which sometimes results from unexpected movements of the palate muscles. It also makes it possible to tie each suture immediately, and saves the necessity for caring for the free ends of the sutures which are more or less in the way if all the sutures are passed before any of them are tied. By following the silver plate that is passed over the free end of the suture with four perforated shot the first one may be clamped at once, and later as the parts yield in the course of progress of the suturing, or as the need of still greater tension relief becomes more apparent the suture can gradually be tightened by clamping the second and if necessary the third shot, still leaving the fourth one for final more accurate adjustment at the end of the operation. If silkworm gut be used for this purpose instead of wire, care must be taken when clamping the last shot not to cut the gut at the silver plate by too much compression.

Exact adjustment in suturing the uvula favors proper alignment of the pharyngeal muscles. This is essential because the outline of the faucial pillars is an important speech factor. Interrupted sutures are used well back into the tissues and care exercised not to tie them too tightly otherwise strangulation necrosis may result. The intervening gut sutures are placed nearer to the border of the palate to favor closer coaptation and where eversion of the mucous membrane shows unprotected tissue along the line of coaptation, horse hair inserted with very fine needles is used to complete, if possible, an absolutely water-tight line of approximation throughout.

Some operators depend upon mattress sutures to relieve tension, and depend upon a continuous suture for approximation. Sinclair Kirk advocates the use of a continuous suture of No. 1 or 2 silkworm gut and claims that it facilitates rapid insertion and relieves the obvious necessity for great care to insert the stitches opposite each other and to tie the sutures with a great amount of tension.[1]

The author has seen beautiful results secured by Berry who supplements a mattress suture by passing it through two short pieces of rubber tubing which are fixed upon each side close to the junction of the hard and soft palates.

Brophy wires two lead plates into position for the same purpose and countless other expedients have been tried to overcome the tendency of palatal tissue to separate unless supported in the right position for a sufficient period of time to establish a dependable line of union.

A ribbon of tape adjusted to encircle the flaps and overcome their tendency to separate, as formerly advocated by Mayo, and modified by Sherman, are efforts in the same direction.

It is inadvisable to cover large surfaces of the palate by the use of

[1] Note on Cleft Palate Operations, British ed. Jour., December 21, 1910. Berry and Legg: Harelip and Cleft Palate, p. 215.

tape, metal buttons, or plates or other similar devices for relieving tension, because if the parts cannot be brought into approximation without undue tension the suture will cut through in spite of the surface protection, and necrosis will result from undue compression of any nature. The accumulation of debris is unavoidable in the buccal cavity under these circumstances, therefore the best cleanliness is impossible, and local infection is much more likely to result than if the parts were left more freely exposed. Inasmuch as a small opening in the central portion of the palate may sometimes occur in spite of every care, it seems to be the part of wisdom to keep the sutures as independent of each other as possible, so that the conditions of the healing process later on may favor the filling in of such

Fig. 394.—Cast of the mouth of a child, showing the contraction and loss of teeth from a compression in early infancy operation and the loss of tissue which makes closure exceedingly difficult.

Fig. 395.—Drawing from the cast of the mouth of a young woman, aged twenty-eight years. Palate was closed by compression in early infancy. Her upper dental arch is so narrow and the palate so high that the freedom of the tongue in speech is so inhibited as to make good speech sounds practically impossible. She has also a corresponding contraction of the nares with marked deflection of the septum.

defect by granulation rather than the extension of the breach in the line of union by the loss of integrity which might result if one continuous suture were depended upon.

Postoperative Treatment.—The less the palate tissues are disturbed after operation the better. The struggling and crying of a child during mouth cleansing manipulations often does more damage to the palate than the microörganisms which might or might not be controlled by this procedure are likely to do harm. A skilful nurse may take advantage of the opportunities offered when the child cries from any cause to observe the condition of the palate sutures. When treatment is required, with all things prepared in advance to avoid delay which may prolong the period of struggle, the child is held firmly and the necessary portions of the mouth touched lightly with applicators dipped in dioxogen for cleansing purposes. If the accumulation of secretions in the nose or other disadvantageous conditions are indicated by the odor of the child's breath and the color of the palate tissue the infant is then placed face downward and its nose flushed two or three times with a solution of boric acid. This must be done quickly and should not be done at all unless absolutely required. Attention should be given to improving general rather than local conditions. The gut sutures are allowed to absorb without interference. The silver plates and tension sutures are removed on the fourteenth day. In adult cases there is always the disadvantage of chronic nasal disease to combat, and usually the nasal accessory sinuses are also in a more or less unhealthy state. These secretions deprived of their former drainage through the open palate fissure sometimes accumulate upon the upper raw surface of the palatal flaps and become a serious menace to the integrity of this tissue. To favor their accumulation upon the posterior wall of the pharynx rather than above the palatal flaps in the newly fashioned floor of the nose, patients are kept lying on their backs as much as possible for a sufficient time to insure complete union.

There are serious disadvantages in connection with the use of fluids for cleansing or antiseptic purposes in this region. It is therefore advisable to use some suitable non-irritant antiseptic oil preparation blown into the nose and mouth with a nebulizer which vaporizes it. This is done frequently not only for the purpose of controlling pathogenic microörganisms but also to prevent bacteria-laden secretions from clinging to the exposed raw tissue surfaces. The oral surface of the palate is kept cleansed by touching it with applicators dipped in dioxogen. The lips, teeth and tongue are treated in the same manner. Liquid sterile nourishment is given by spoon and the patient is instructed to learn to swallow with as little movement of the pharyngeal muscles as possible. It is well to prevent speech effort at this time and to provide a pad and pencil to serve the purpose of communication without speech.

The battle in palate cases comes as a rule between the fourth and eighth days and it is the necessary protection during this period toward which operative or postoperative efforts must be directed.

Surgical Correction of Postoperative Palate Defects.—The most common defects found in palates that have been previously operated upon without complete success are shown in Figs. 394 to 397. The most difficult conditions to contend with are found among individuals who have been operated on in early infancy by compression to force the maxillary bones together. In addition to such defects as those shown in the illustrations they almost invariably have serious nasal defects also, and often give a history of middle ear and mastoid affections as well as mouth irregularities due to contracted palates and the loss of tooth germs through the insertion of the retaining wires. The treatment of these mouths naturally involves questions which pertain to health, as well as speech and nasal deformity. Continued patient

Fig. 396. — Illustration prepared to represent as nearly as possible the unequal division of the soft palate which has resulted from the destructive process following imperfect early operations, and which makes operative conditions much more difficult.

Fig. 397.—Illustration representing the condition of the mouth of a boy, aged twelve years. His first operation was performed in infancy. Following this several other unsuccessful operations were made in attempt to close the palate fissure before he came under the author's care. The unequal muscular activity had been militating against success. This fibrous band of tissue was freed with the underlying periosteum and muscular readjustment accomplished when these openings were closed. The result is that at his present age, seventeen, this young man can speak almost without the slightest trace of speech defect.

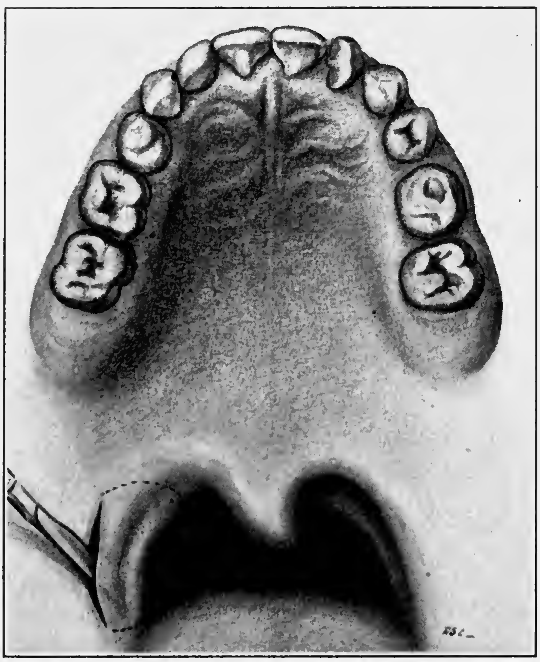


Fig. 398.—Drawing of the palate of a young woman, aged twenty years, whose faucial pillars were injured in the course of a tonsil operation, shows shortening and deflection of the palate, fluids escaped through the nose in swallowing and speech very imperfect.

effort following the lines of established methods of palate operation will finally result in the complete closure of all such postoperative palatal defects, and when the palate is closed, expansion of the dental arches can do much to restore both cosmetic appearance and phonation.

Phonation.—In this relation it must be remembered that there are many speech influences other than those which directly concern the functional activity of the palate. The mechanism of speech involves not only the perfect anatomical coöperation of the vocal cords, the respiratory muscles, the auditory apparatus, and the sound governing influences of the nose and nasal accessory sinuses as well as the tongue, teeth, lips, cheeks and pharyngeal muscles, but the nerve control of all

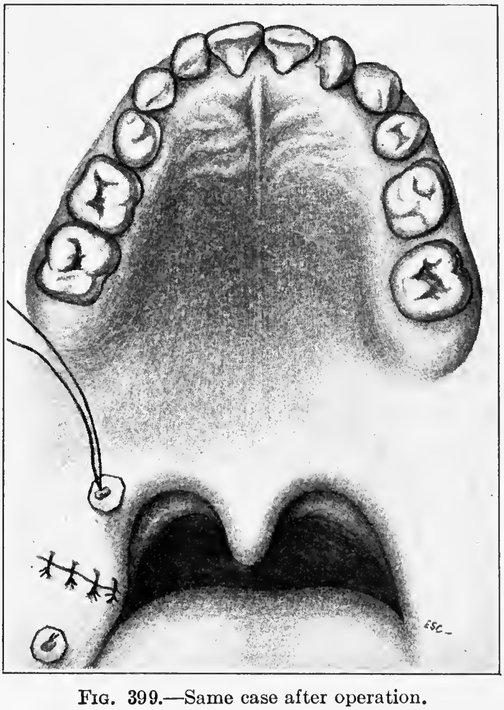


Fig. 399.—Same case after operation.

these elements as well. It therefore follows that the most successful method must be one that favors pharyngeal development which will give the best form to these anatomical parts and also the nervous conditions which control their physiological activities.

With infants of sound mentality whose palates have been closed before speech habits have been acquired there should be good phonation if the form and muscular alignment of the palate is sufficiently perfect. When this result is not secured it is because there has been some interference with the natural form of the dental arches, the nose or palate or the palatal muscular alignment has not been sufficiently perfect. In cases operated upon after speech habits have been acquired as in older children or adults there should be some noticeable improvement immediately following the palate closure, and they may speak with less effort, but the defective speech sounds due to early acquired wrong speech habits will not be overcome immediately. Benefit in this respect depends upon training and the improvement which usually follows in the course of time. This may be due to conscious or unconscious influences. There can be no doubt of the beneficial possibilities of the postoperative speech-training of these individuals, but the simpler the method used in this direction the better it will be for accomplishing improvement.

The author's observation leads him to believe that the more perfectly the palate may be adjusted and the more natural the true speech relation of nose, palate, tongue and pharynx may be approximated the less need there will be of speech-training and the more perfect the final speech result will be. Perfection in palate form is of paramount importance, and more often determines the speech results following cleft palate operations than the speech habit difficulties which have hitherto been considered of first importance.

The editor has found it possible for children who had so thoroughly established faulty habits of speech before the operation that it seemed impossible for them to change, to acquire perfect speech by employing the following plan: In families with means the child was placed among children speaking a different language, which was easily accomplished by having the child taken to a foreign country, it being understood that whoever accompanied the child must also invariably use the foreign language. After using a foreign language exclusively for one year or longer the child will relearn its own language without its former defects.

In the case of poor people it is usually possible to have the entire family make use exclusively of the language of the country from which they have emigrated, but in this case it is necessary to eliminate the child's former playmates, which can be most easily accomplished by a change of residence.

The Surgical Correction of Palatal and Pharyngeal Defects Following Tonsil Operations.—*Partial Paralysis.*—Impairment of the motor enervation of the muscles of the velum and the pharynx which occasionally follows operative procedures in this region may have a tendency to correct itself in the course of time through reëstablishment of the nerve supply. The loss of tissue from the faucial pillars and the velum not infrequently results from extensive sloughing through infection following tonsil operations. This also occurs through the unintentional removal of portions of the palatoglossus or palatopharyngeal muscles by the cutting across of one or both of these pillars in the course of operations in this region. In these cases the soft palate is drawn to the opposite side and greatly shortened through contraction upon the side of the injury. The effect is most distressing inasmuch as there is a tendency for liquids to come through the nose in attempts to swallow and speech becomes markedly defective. (See Figs. 398 and 399.)

Atresia of the Palatopharyngeal Opening.—Adhesion of the soft palate to the posterior wall of the pharynx may result from syphilitic ulceration or from the destructive activities of other infections. The same condition may also result from unskilful operations for the removal of tonsils through the creation of raw surfaces which may come into apposition and lead to partial or complete closure of this

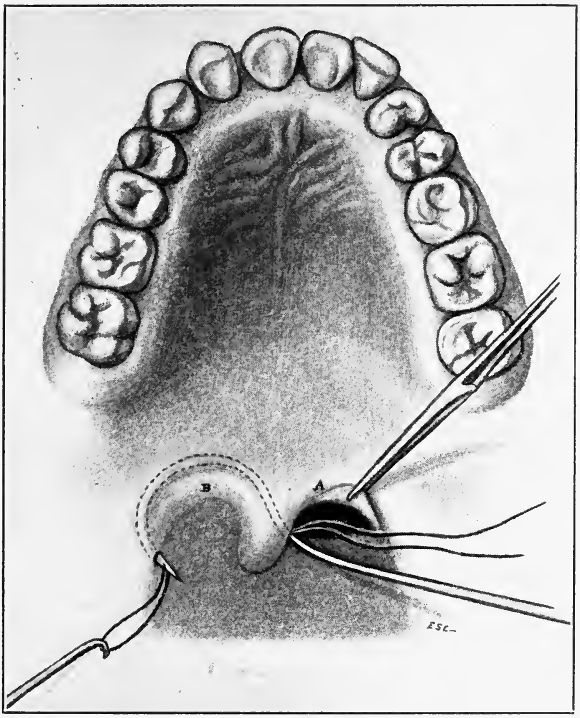


FIG. 400.—Atresia of the palatopharyngeal opening. Case of a boy, aged nine years. The soft palate was adherent to the posterior wall of the pharynx on the right side, a very slight opening being left upon the left side. A number of attempts to correct the trouble resulted in failure, among these being the ill-advised, though sometimes recommended attempt to transplant mucous membrane to cover the raw posterior surface of the palate. Such efforts in these cases are useless. Mucous membrane does not transplant well, the tissues are always distorted when the incisions are made so that perfect coaptation is impossible, and there is always infection to attack the transplanted tissue. During several years of enforced mouth-breathing, nasal disease had become marked, the nares narrow and the septum deflected. As a first step the maxillæ were separated, the nares thus enlarged, the deflected septum relieved and more healthful nasal conditions secured. Following this, operation was performed as shown in the illustration, with complete relief.

portion of the post-nasal space. The accumulation of nasal secretions in the pouch-like form of the nasal pharynx thus established and the ill effect of this upon the associated parts as well as the defective speech which is unavoidable under these conditions all combine to render this condition extremely troublesome. Figs. 400, 401 and 402 illustrate operative procedures that the author had devised and found exceedingly useful in these cases

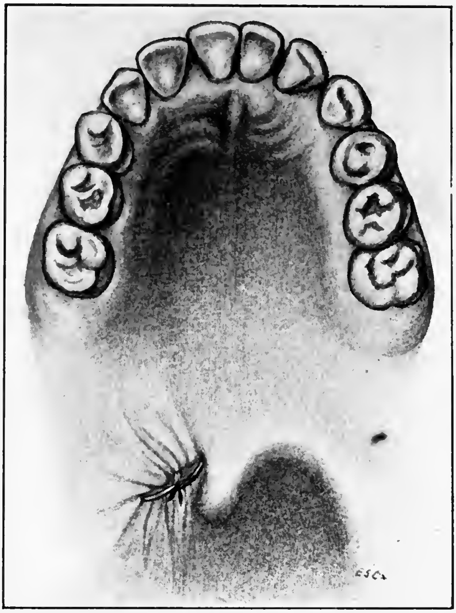


FIG. 401.—The same case as in Fig. 400, after correction. The usefulness of the parts in swallowing and speech was completely restored.

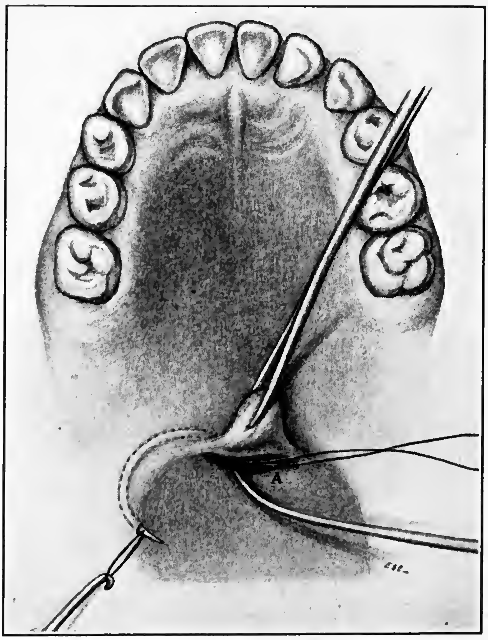


FIG. 402.—Illustration of the pharyngeal opening of a child, aged six years, resulting from a tonsil operation. The soft palate on both sides in this case is adherent to the pharyngeal wall. The small opening just under the uvula is shown.

Fig. 403.—Radiogram of the mouth of a young man, aged twenty-two years, with cleft of the hard and soft palates. Shows the appearance of an open palate fissure in a radiogram.

Fig. 404.—Radiogram of the palate of a young woman, aged twenty-six years, for whom an acquired opening in the anterior portion of the hard palate and in the soft palate due to syphilitic ulceration was closed in January, 1913. By comparison with Fig. 403, taken with an open palate fissure, the bone development may be appreciated.

Fig. 405.—Radiogram of the palate of a young man, aged twenty-two years, taken six years after the fissure was closed with mucoperiosteal flaps so adjusted that the periosteum was preserved in its normal relation to surrounding parts. By comparison with Fig. 403, taken with the fissure in the palate open, the bone development is more clearly understood.

FRACTURES OF THE JAWS.

The varieties of jaw fracture as in other bones are classified as *simple, compound, multiple, comminuted,* and *complicated; impacted, incomplete, green-stick, pathological,* when due to preëxisting disease; *subperiosteal,* as sometimes found in cases of young children when fracture of the bone does not include separation of the overlying periosteum; *intrauterine,* when by reason of a weakend osseous system the offspring of mothers affected by scurvy, syphilis and similar disease may suffer fracture before birth. In *alveolar fractures* the alveolar process is split or fractured without involving other portions of the maxillary bones. Fractures are further described as *recent, old, united* and *ununited.*

Etiology.—The *superior maxillæ* are so surrounded and supported by the other facial bones that they are seldom fractured in civil life except through some more or less unusually forcible injury as a fall from some height. Automobile, motor cycle and railway accidents, horse or man kicks, machinery accidents, gunshot wounds, etc., occasionally produce fractures of this bone. Comminuted fractures are therefore usual in these cases.

The *inferior maxilla* is more exposed and much more subject to fracture than its superior associate. The weakest point in a normal lower jaw is slightly anterior to the mental foramen and in an edentulous jaw at or in line with the mental foramen. Fractures in the region of the third molar teeth frequently occur as a result of ill advised efforts to extract these teeth. This is the only unusual factor in fractures of the jaws when compared with other bones.

FIG. 406.—Fracture of tooth and jaw; tooth becomes infected and must be removed. (Dunning.)

Symptoms.—The objective symptoms are deformity, unnatural mobility, crepitus, loss of function, increased salivation. The subjective indications are pain on attempting movement, tenderness to pressure at the point of fracture, inability to speak and swallow without difficulty. In diagnosis it will be noted that the teeth are out of alignment, there is unusual movement, and crepitus as the bone ends are rubbed against each other. The value of the *x*-ray as a diagnostic aid in these cases is shown in Figs. 406 and 407.

Treatment of Fractures of the Maxillæ.—The methods of retaining fractured lower jaws are as follows: (1) By bandaging alone; (2) by ligating teeth upon each side of the fracture as first done by Hippocrates and used in one form or another ever since; (3) by splints constructed of metal, plaster of Paris, or other suitable material laid upon the external surface of the chin, the side of the jaw or behind the angle with a few layers of cotton pad to prevent irritation and firmly bandaged; (4) by interdental splints, *i. e.*, supports placed between the jaws, a method first used by Hayward in 1858 and modified and improved by Gunning in 1861; (5) by attachments to or upon the teeth of the affected jaw only; (6) by wiring the teeth of both jaws together; (7) by wiring the bones, of which a successful case was reported by Buck, 1847; (8) by bone plates.

Fig. 407.—Fracture of condyle showing partial dislocation. (Dunning.)

In deciding upon the splint or appliance that may be used to hold the fractured bony parts in position there are certain important principles which must be kept in view to govern selection. These in the order of their relative importance are as follows: (1) Perfect approxi-

Fig. 408.—Gunning's interdental splint with opening for introducing food. This form of interdental splint may be made of dental impression compound for temporary purposes of vulcanized rubber for permanent use. The jaws are held in contact with this splint by figure-of-eight four-tailed or other suitable bandage.

mation of the parts; (2) immobility; (3) freedom in taking nourishment; (4) facility in keeping the mouth surfaces clean; (5) the possibility of frequent observation of the parts; (6) freedom in the use

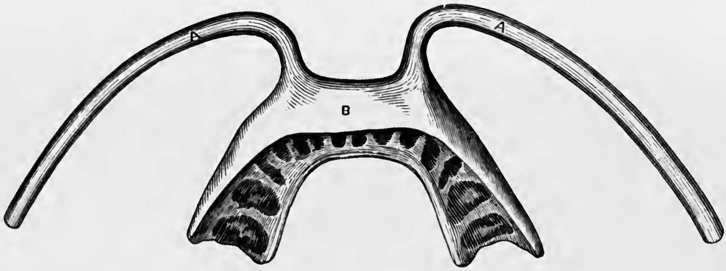


Fig. 409.—Kingsley's interdental splint. This gives fixation in upper jaw fractures with freedom of the lower jaw. The appliance is made of vulcanized rubber into which wires that pass around angles of the mouth and extend outside the cheek surfaces are embedded. To these are attached elastic bands which pass over the head.

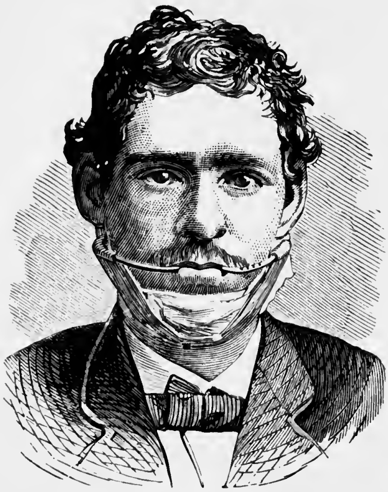


Fig. 410.—Kingsley's splint applied.

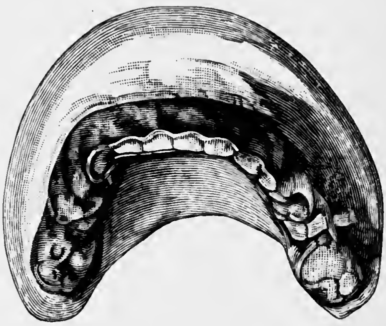


Fig. 411. — Dental splint applied to cast. A continuous thin metal splint made to fit over all of the teeth in the affected jaw and cemented into place. This splint gives the utmost security and comfort.

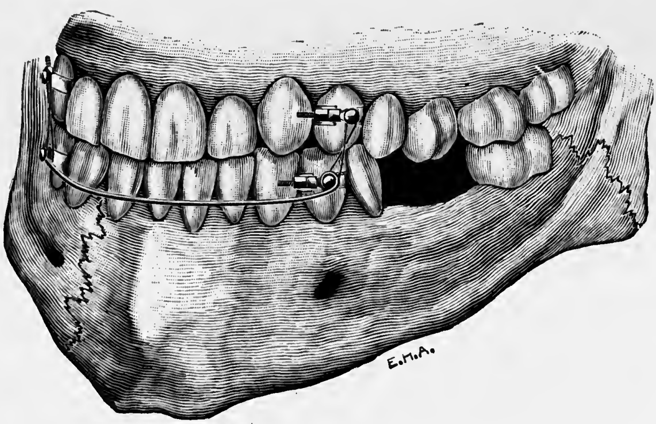


Fig. 412.—Splint for fractured lower jaw. (After Angle.)

of the jaws, which necessarily implies their not being bandaged or bound together by wires.

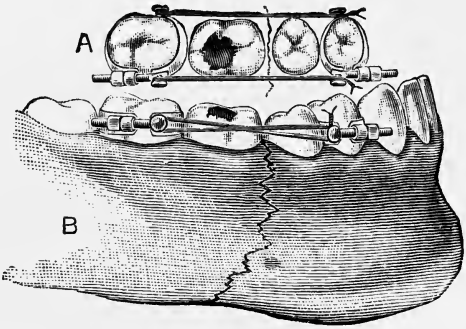


Fig. 413.—Splint for fractured lower jaw. (After Angle.

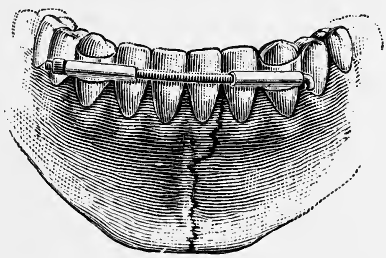


Fig. 414.—Splint for fractured lower jaw. (After Angle.)

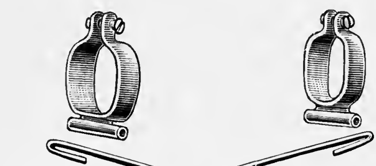


Fig. 415.—Löher's splint.

In some forms of fractures all of these desirable conditions can be secured, and in others this is impossible. It therefore becomes necessary to select the kind of splint that will give the greatest possible comfort to the patient with the best promise of a good result by securing as many of these advantages as may be practicable. With these principles in view selection may be made without difficulty from the illustrations shown in Figs. 408 to 444.

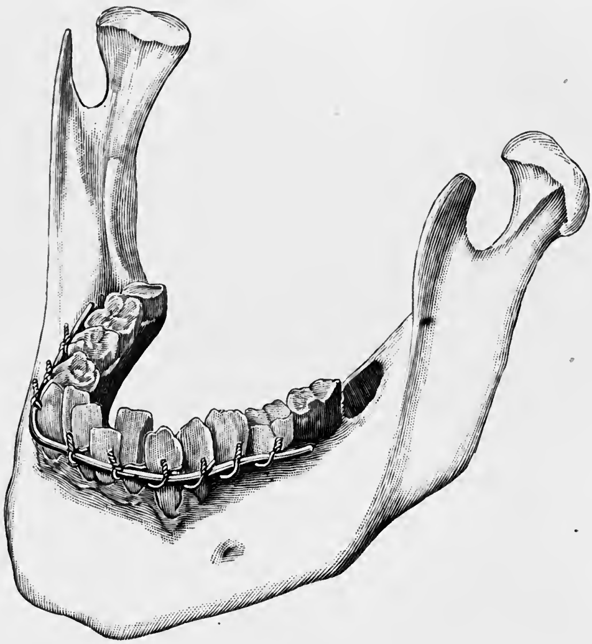


Fig. 416.—Sauer's splint.

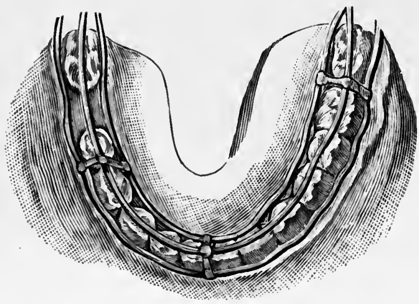


Fig. 417.—Martin's splint.

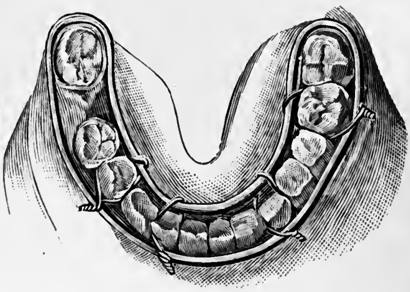


Fig. 418.—Hammond's splint.

Temporary Splint.—On account of swelling and tenderness to touch or because of the critical condition of the patient through other effects of the injury causing the fracture it may be practically impossible to adjust a splint with sufficient accuracy to give a symmetrical result. Pain and other discomforts often demand an immediate fixation to give the patient much needed relief.

Under these circumstances the author has found great satisfaction in the application of an interdental splint, prepared immediately with dental impression compound which can be softened in warm water, quickly moulded into suitable form and then made to serve the purpose of a splint until the improved local or general condition makes it possible to insert a satisfactory permanent appliance.

FIG. 419.—Shape of splint before being fitted to chin. (Roberts.)

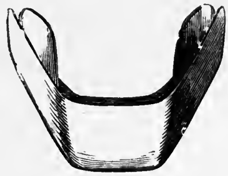


FIG. 420.—Splint moulded to fit chin. (Roberts.)

FIG. 421.—Modified Barton's bandage. (Wharton.)

Army Temporary Splint.—An improvement on this plan of using dental modelling compound for emergency jaw splints is shown in Figs. 439 and 440.

Preparation of a Cast of the Mouth for Splint Construction.—In constructing an interdental splint from a cast of an impression of the mouth the necessary disarrangement of the parts may be overcome by sawing through the cast to permit the correct adjustment in occlusion of the teeth with a cast of the opposite jaw.

Kingsley's Method.—When this is done, the splint will bring the parts into such position that a good alignment of the teeth will be assured, otherwise there may be marked deformity in this respect after union has taken place.

Complications.—In compound fractures of the maxillæ there is always certainty of infection from microörganisms in the oral secretions. In other respects the adverse conditions which are accountable for delayed

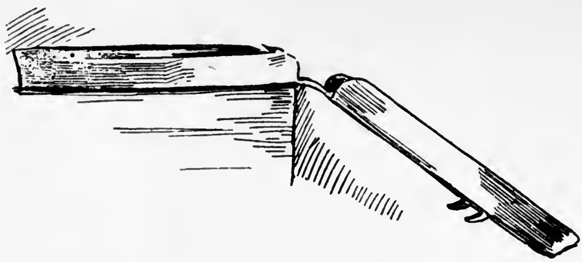


FIG. 422.—Emergency splint designed by Col. Vilray P. Blair and adopted by the U. S. Army. (Courtesy of the Detroit Dental Manufacturing Company.)

FIG. 423.—A splint bent to the required form and filled with modelling compound and ready for insertion. (Courtesy of the Detroit Dental Manufacturing Company.)

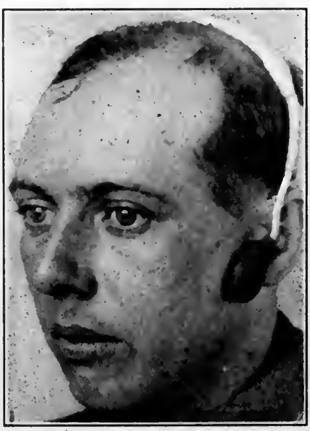


FIG. 424.—Riley's appliance for chronic dislocation of the lower jaw as applied in the case of a wounded soldier.

union, malformation of the parts, injuries to nerves and bloodvessels, necrosis from comminuted bone fragments and similar disadvantages, are the same as in other fractures.

The complications which do not occur elsewhere are from the devitalization of tooth pulps through the effect of traumatic injury destroying their nervous and vascular connections at the apical ends of the roots. This should always be keep in mind. Over and over again the author has found fistulæ which would not close delayed union because pus followed the line of fracture, and serious necrosis of the jaws which were traceable to gangrenous pulps in the teeth adjoining or associated with the fracture. The immediate extraction and treatment of such teeth is absolutely necessary.

Ludwig's angina, extensive abscesses in the region of the neck and salivary fistulæ may occur from the infection of compound fractures. Ankylosis frequently results from fracture of the condyle.

Reduction of the Fracture.—Under favorable conditions the antagonism of the digastric geniohyoglossus and mylohyoid muscles upon the one hand, and the masseter, temporal, and pterygoid muscles through which disarrangement of the parts occurs, may be overcome with little difficulty, but when the conditions are unfavorable through tense contraction of the muscles due to irritation, pain, extreme nervousness of the patient, swelling and other disadvantages, it may be necessary to administer an anesthetic in order to secure accurate reduction of the fracture with proper alignment of the teeth.

Period of Fixation.—The time required for complete union to take place must be governed by the conditions of the case. There is necessarily great difference in this regard between simple uncomplicated fractures in favorable situations and those that are compound, or multiple or comminuted and difficult to control. Infection also is a governing factor in this regard. The average time during which a splint may be required to be worn is approximately thirty days.

In cases of uncomplicated fracture after the adjustment of a splint such as shown in Fig. 425 the author has known patients to go directly home and eat a full dinner without discomfort. Under less advantageous conditions, liquid nourishing food may be required. The mouth must be washed with a suitable antiseptic solution and whenever possible wiped with applicators dipped in dioxogen. The danger of inspiration pneumonia should be guarded against as well as that of general sepsis. For this reason wiring the jaws together, wiring the bones and interdental splints requiring bandages should be discouraged in favor of splints that may accomplish fixation and yet give greater freedom in the use and treatment of the jaws. The removal of splintered portions of bone or sequestra may be important.

In case the bone has been severely fragmented and the soft tissues show extreme bruising it is well to support the patient in a sitting position in bed and to place a sheet of rubber dam about the neck with its lower end in a vessel to collect the irrigating fluid. Then a glass tube with a bulbed end is attached to an irrigation apparatus suspended from a point above the bed and normal salt solution is permitted to enter the mouth in a small continuous stream until the wound has begun to granulate and until the wound can be kept clean by periodic irrigation.

Fig. 425.—Fracture of the upper maxilla extending from the cuspid upward and backward to include all the posterior portion of the jaw. The man fell from a roof of a house and struck upon his face, causing not only fracture but great distortion of the parts. Splint shown in place, is attached to the last molars on the fractured side, one of the incisors, and the cuspid tooth on the opposite side. These were connected by metal bars made adjustable through the use of nuts and screws and the appliance cemented in place. By turning these nuts an accurate adjustment of the parts was easily accomplished. In restoring the normal occlusion of the teeth, an improved facial appearance was acquired. Fixation was absolute and he was able to eat solid food as soon as the soreness resulting from the traumatism disappeared.

Fig. 426

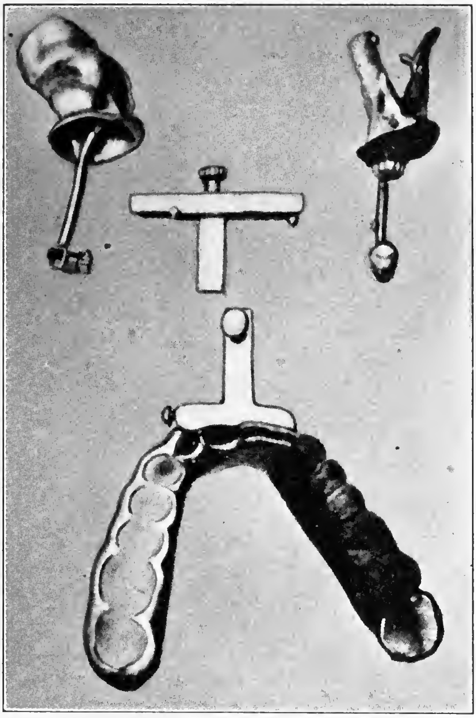


FIG. 427

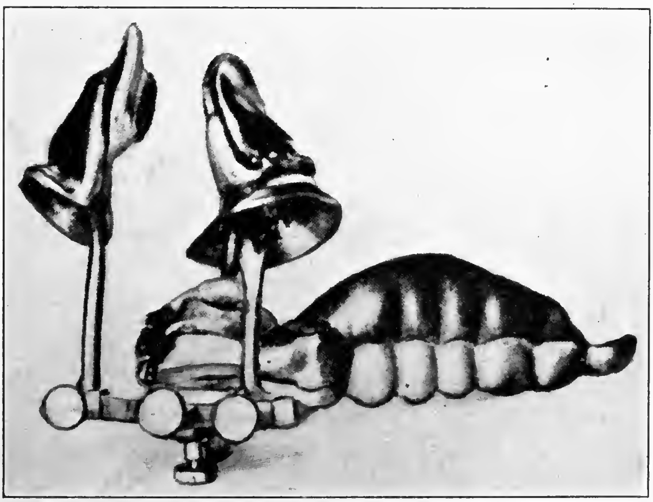


FIG. 428

FIGS. 426, 427 and 428 illustrate a case reported by Major Fernand LeMaitre,[1] showing nasal splints, supported by a prosthesis in the mouth, which were very successfully used to prevent nasal stenosis and marked facial deformity. Fig. 426, appliance in place. Fig. 427, the apparatus in detail. Fig. 428, the prosthesis complete, with parts assembled.

[1] La Restauration Maxillo Faciale, par V. H. Kazanjian, Major, Harvard Surgical Unit, February, 1919, p. 22.

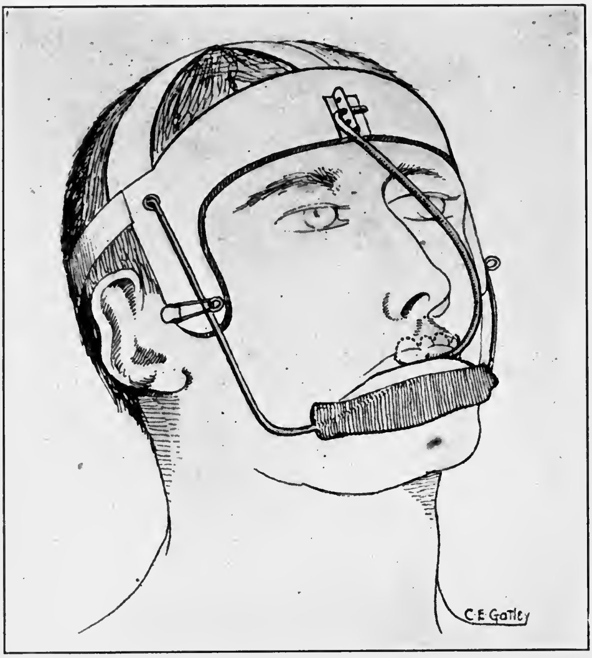


Fig. 429.—The external lip support consists of a piece of gutta-percha molded to the lip and attached to an irregular U-shaped wire. The ends of the wire are bent at right angles and inserted in the headgear at the temporal region, while elastic bands applied at the level of the ear cause backward pressure on the lip. In this case, the median wire is soldered to a removable upper cap splint in order to give the necessary security.[1]



Fig. 430 Fig. 431 Fig. 432

Figs. 430, 431 and 432.—Case of a man, the entire anterior part of whose mandible was torn away by war injury. Fig. 430, as it was after first-aid operative treatment. Fig. 431, prosthetic appliance inserted in the mouth to hold the jaw fragments apart and over which the soft parts were molded. Fig. 432, the result of a first corrective operation which gave sufficient restoration to make possible more perfect correction of the lower lip later on.

[1] La Restauration Maxillo Faciale, par V. H. Kazanjian, Major, Harvard Surgical Unit.

The position will prevent hypostatic congestion of the lungs at the same time that the continuous irrigation prevents inspiration of septic material.

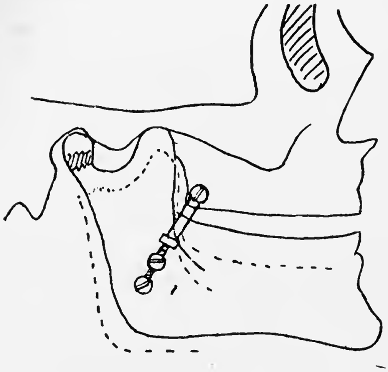


FIG. 433.—This figure illustrates the effect of downward pressure from a point of attachment in the superior maxilla.

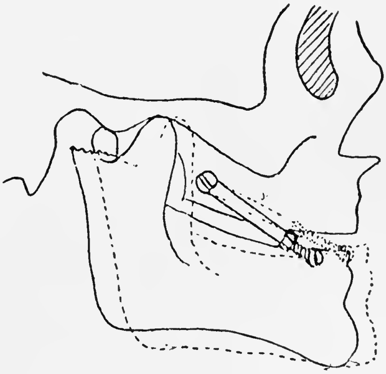


FIG. 434.—This figure illustrates the necessary downward and forward or propulsive force.

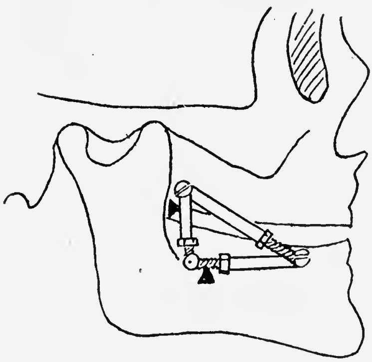


FIG. 435.—This figure illustrates an appliance which has been more or less widely used as designed by Villain, and can be attached to plates in both jaws and is capable of exerting both downward and forward pressure while at the same time it permits a reasonable amount of jaw movement.

FIGS. 433 to 435.[1]—These figures illustrate the principles of the treatment by Georges Villain of what he calls post-élévateur fractures of the mandible, or fractures above and behind the attachments of the masseter muscles, more particularly in the region of the neck of the condyle.

Fractures of the ramus, if not complicated and properly reduced, will usually be held in position by the action of the masseter and pterygoid muscles without the aid of a splint. When both the rami are affected, fixation of the jaw is required.

Fracture of the neck of the condyle can be reduced and the parts held in position by the extension of the jaw forward in the horizontal plane

[1] Villain, Georges: La Restauration Maxillo-Faciale, June, 1917.

and pressure from behind to reduce the fracture. The splint used should be one that is capable of exerting propulsion. Figs. 433, 434 and 435 illustrate the method of Georges Villain, of Paris, for accomplishing this purpose.

Complete unilateral obliteration of both condyloid and coronoid processes will only partially disable the masticating usefulness of the mandible if the opposite side be intact.

War Injury Jaw Fractures in Great Numbers.—The great number of war injury jaw fractures that required treatment during the recent world conflict from gunshot, shrapnel or other high explosive wounds, aëroplane accidents and similar unusual traumatic injuries, resulting, as they did, in an infinite variety of compound comminuted jaw conditions, often with loss of large sections of bone, have, by the very urgency of the existing necessities, brought forward many ingenious devices for retention and fixation that are equally applicable to the jaw fractures of civilian life.

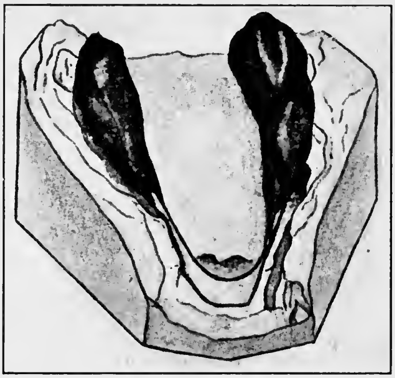


Fig. 436.—Appliance designed for cases in which there is extensive loss of bone from the anterior portion of the mandible when no lower teeth are available for purposes of retention. It preserves the remaining parts of the mandible in an anatomical position and also prevents undesirable adhesions at the site of injury. After healing has taken place this splint is followed by one of the types shown in Figs. 437 and 438.[1]

Experience with hundreds of these cases, as the men were returned to U. S. Army General Hospital No. 11, at Cape May, New Jersey, and at the Walter Reed Hospital, Takoma Park, Washington, D. C., from all parts of the European War Zone, has led the author to believe that many of the methods of retention and fixation thus originated are so valuable as to warrant their substitution for older methods, even though the general principles of their application and construction may be more or less identical.

The association of nasal and other facial bone displacements with fractures of the maxillæ has required splints that would support all the injured bones as well as the maxillary structures. Supplementary attachments to prosthetic appliances in the mouth to hold the over-

[1] La Restauration Maxillo Faciale, par V. H. Kazanjian, Major, Harvard Surgical Unit No. 11, November, 1918, p. 34.

lying soft parts, as well as the maxillæ in normal position, or to serve as molds over which the tissues could be formed in plastic operative restoration, have also been extensively employed with wonderful success, and are therefore entitled to reproduction in this relation. Examples of these are shown in Figs. 436, 437 and 438.

FIG. 437.—Appliance designed by Kazanjian for cases in which there is extensive destruction of the mandible confined to one side. The lower restoration is hinged at the middle and after introduction to the mouth, is spread and locked by a lingual bar which rotates at one end. To prevent a backward rotating motion of the plate in the mouth, an artificial condyle is attached, which consists of a bar originating at the palatal surface of the upper molar region of the upper plate, and a curved bar below on the lingual aspect of the lower plate. The upper bar is allowed restricted movement by being adjusted in a small tube while the lower is fixed. The upper bar operates posterior to the lower; and the curves of each are designed to give as free and natural movement to the jaws as is possible.[1]

Pseudarthrosis.—The causes of delayed or faulty union of fractured bones with the establishment of fibrous tissues between the bone ends are chiefly imperfect immobilization, imperfect approximation or the interposition between the bone ends of periosteum, muscle or other soft tissue and infection. The difficulties of securing complete fixation and failure to secure good approximation are greatly increased by many adverse factors; most commonly, however, these conditions are directly due to loss of bone substance, edentulous jaws, the situation and character of the fracture. Septic conditions are frequently long continued because of the presence of devitalized teeth or roots or fragments of dead bone which for some reason cannot readily be exfoliated. In the war cases bits of shrapnel, lead from bullets, particles of clothing and other foreign bodies that had been driven into the tissues were frequent causes of this trouble.

[1] La Restauration Maxillo Faciale, par V. H. Kazanjian, Major, Harvard Surgica Unit No. 11, November, 1918, p. 34.

The treatment of pseudarthrosis consists in correction of the cause by removal of foreign bodies, dead bone, if present in the tissues, correct approximation, firm fixation and the excision of fibrous or other interposing tissue between the bone ends, with sufficient freshening of the bone surfaces to favor prompt union when placed in direct contact and bone-grafting when bone fragment contact is impracticable.

Complete Loss of Segments of Bone from the Jaws.—The characteristic indications of the absence of bone from the mandible are malposition of the teeth in occlusion and the jaw drawn to the affected side in addition to the loss of function.

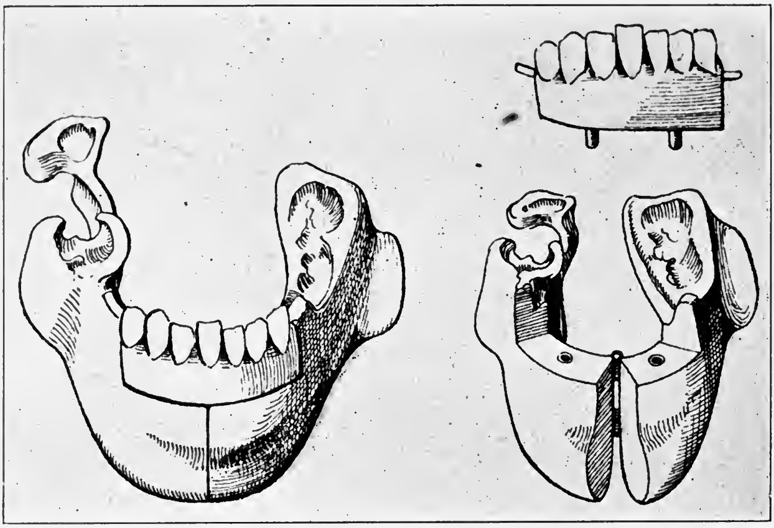


Fig. 438.—Appliance (designed by C. H. Kazanjian) used as a substitute for missing portions of the mandible. It is hinged at the middle to allow its collapse and introduction into the mouth, and when spread to position it is locked by the vulcanite section carrying teeth.

A wide diversity of opinion existed among surgeons in overseas hospitals as to the advisability or inadvisability of bringing the bone ends together without regard to loss of form and immediately suturing the overlying tissues; the arguments in favor of this treatment being that much danger of infection might thus be avoided and the soldiers permitted to make more prompt recovery.

The opponents of this procedure held that at all costs the bone fragments must be held as nearly as possible in their right relation, so as to preserve not only the form and occlusion of the jaws but also the appearance of the face. Splints with attachments to keep the jaws in alignment, and at the same time to permit a sufficient amount of freedom of movement, are illustrated in Figs. 439 to 442. It is safe to say that the advocates of both these methods were right and both were wrong. Sometimes one procedure would be indicated and sometimes the other.

In fractures with loss of a section from the horizontal body of the mandible close to the ramus it was found that such a wound under favorable circumstances could be closed immediately, with much less disarrangement of the occlusion of the teeth and other disadvantages

Fig. 439 Fig. 440 Fig. 441

Figs. 439, 440 and 441.—Three different types of splints in the mouths of returned soldiers to preserve the jaw alignment in cases of mandibular pseudarthrosis due to loss of bone substance. Fig. 439, splint attached to lower jaw with guide sliding outside the upper teeth on the left side with pseudarthrosis of the mandible on the right side. Fig. 440, splints on both upper and lower jaws with corrective guide to overcome the effect of the loss of a large section of bone from the opposite side of the mandible. Fig. 441, crowns on teeth of both upper and lower jaws with hooks on the labial surfaces to wire with the jaws together.

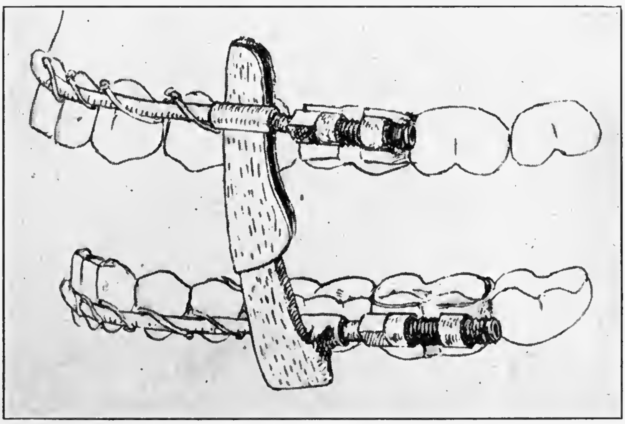


Fig. 442.—Schröder's guide for cases of mandibular pseudarthrosis with absence of a section of bone shown with the mouth open.[1]

to the patient than might be expected because of the muscular readjustment which takes place after firm union has been secured. The ramus is capable of moving forward to a very considerable extent in a natural effort to correct the malocclusion, providing it can be allowed to slide

[1] La Restauration Maxillo Faciale, April, 1919, p. 255.

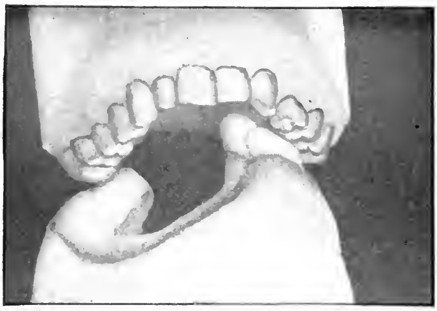


FIG. 443

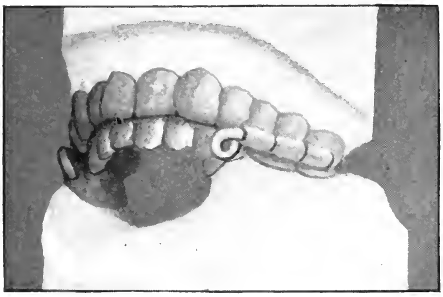


FIG. 444

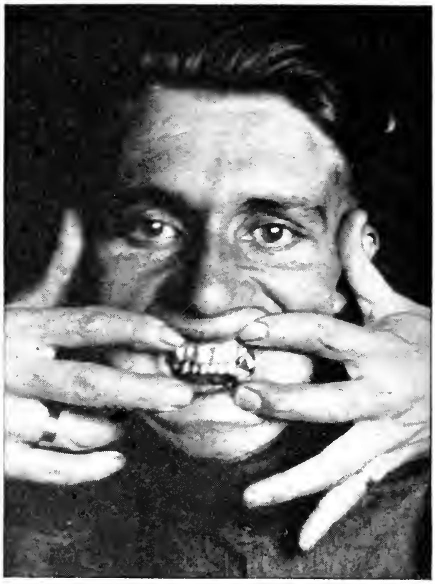


FIG. 445

FIGS. 443, 444 and 445.—(Shown by courtesy of Lieutenant McCauley, formerly of General Hospital No. 11, Cape May, New Jersey, and the Dental Cosmos.)

FIG. 446

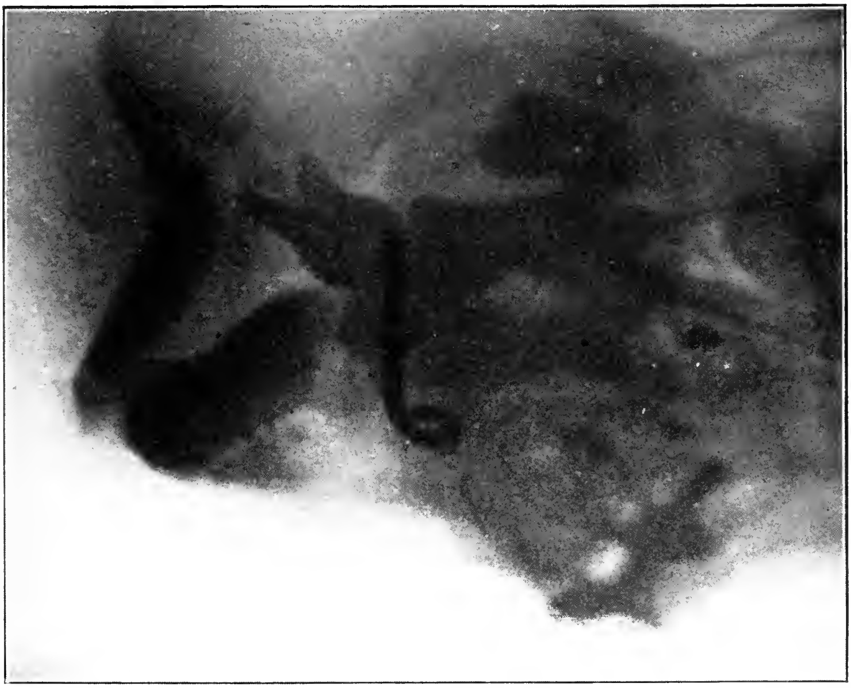


Fig. 447

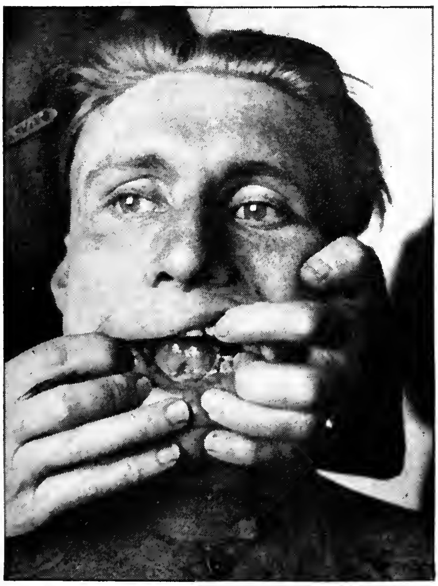


Fig. 448

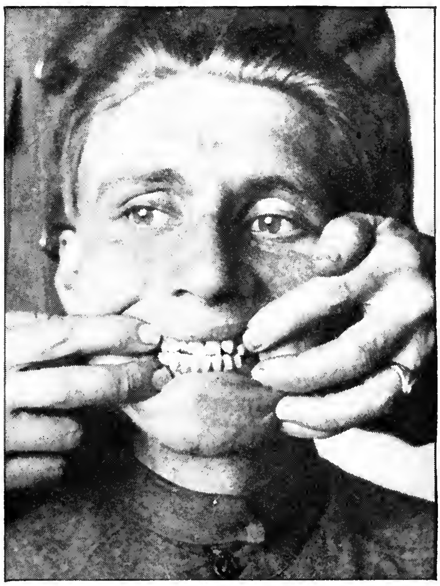


Fig. 449

Figs. 446 to 449.—Illustrations of the case of a soldier with loss of bone from the mandible by gunshot wound in whose case a bone graft according to the Albee method was inserted by the author and reported by McCauley and Worthley in the Dental Cosmos for May, 1919. Fig. 446, radiograph showing bone destruction (December 1, 1918). Fig. 447, radiograph with bone graft in place (January 15, 1919). Fig. 448, jaw after the graft has united without the prosthesis in place (March 10, 1919). Fig. 449, removable bridge-work denture inserted and worn over the grafted surface after firm union had taken place.

forward outside of the superior maxillary without interference by meeting the maxillary tuberosity on the affected side.

McCauley after experience with 147 cases of fracture, with loss of substance occurring in the body of the mandible in which the posterior fragment has been drawn forward, states that when the ramus is intact and the loss of bone is from 1 to 3 cm., and if firm teeth are present in the posterior fragment, it is very easy to immobilize the parts. But if no teeth be present and the posterior fragment has not moved forward of its own accord, and if the loss of bone be not greater than 3 cm., an open operation should be performed and the fragments drawn together.

Fig. 450 Fig. 451

Fig. 450.—Congenital fibrous band extending from the jaw to the clavicle, causing deformity shown and rendering it impossible to hold the head comfortably in an upright position. The divided jaw was fixed with a splint attached to the teeth.

Fig. 451.—Same girl shown in Fig. 450. After correction of the defect by a transverse incision at a point just above the thyroid cartilage through the fibrous band and after freeing the surrounding tissue the skin was drawn from the central portion of the incision above and below, upward and downward until when brought together the line of incision was perpendicular instead of parallel. A slight trimming of the skin at each end of the suture line was necessary in order to complete the outline of the neck.

The advantage of immediate early closure when extensive soft tissue wounds are involved is, of course, obvious. In other cases it is necessary at all costs to keep the bone fragments apart and in the best possible approximation to their normal situation in order to conserve usefulness of function and cosmetic appearance.

Devices that were used to successfully meet these conditions are shown in Figs. 439 to 442. When healing had been satisfactorily completed and a sufficient time allowed to establish circulation of the parts (many months were often necessary), and after the overlying plastic restorations have been sufficiently completed, the proper remedy lies in bone-grafting.

The pin-and-tube splint, shown in Figs. 443, 444 and 445, according to the author's experience, was found to be the best of all the splints that in infinite variety were found in the mouths of the returned soldiers whose cases had been treated in so many different ways and under such diversity of conditions. It permits opening the mouth in case of vomiting during the operation, with certainty of exact replacement of the parts when the jaws are closed. It gives both the extension and fixation against contraction, drawing the jaw to one side that is afforded by the other forms of splints. It is simple, cleanly and efficient for its intended purpose.

Bone-restoration may be accomplished by bone-grafting, according to the Albee methods, as shown in Fig. 459, by inserting a bone-graft from the tibia containing all the layers of bone and the overlying periosteum, placing this graft in dove-tails cut into the jaw fragments at each side and securing it there with kangaroo tendon sutures, after which the overlying parts were closed. Absolute immobilization of the jaw during the period of bone formation is required and septic infection must be avoided. The graft is placed through an outside incision along the jaw. Careful dissection is required to free the bone ends without entrance into the cavity of the mouth, Such grafts are almost uniformly successful, as shown in the author's cases illustrated in Figs. 446 to 449.

Osteoperiosteal grafts, which contain the periosteum and a thin underlying bone shaving, have been extensively and quite successfully used for mandibular restorations. Two and in some instances three of these grafts are cut the size of the required space to be covered, with the periosteum slightly larger than the bone-shaving to which it is attached. One graft is placed with the periosteal side turned inward and the other on the external surface, with the periosteum outward; if a third segment is used it is forced in between the other two. They are secured by suturing the graft periosteum border to the periosteum of the bone to be grafted.

Le Maitre and many other operators have employed the method of these grafts successfully in large numbers of cases. Figs. 450 and 451 show one of the author's cases with a divided mandible in which pseudarthrosis had existed for many years, now united by an osteoperiosteal graft.

Pedicled flaps according to the method of Cole, have much to recommend their employment in suitable cases. The illustrations shown in Figs. 452 to 458, through the courtesy of Major F. J. Tainter, are self-explanatory.

One hundred per cent. success is claimed for the pedicled bone graft because of the better blood supply afforded by the attached pedicle. When the entire anterior portion of the mandible has been lost, respiration is often a serious factor when a general anesthetic is administered; but with the patient in an upright position or with the tongue held forward this difficulty may be overcome.

In grafting these cases the Albee method of cutting a semicircular section of bone, the upper border of the ilium serves the purpose better than any other bone graft. The external plate and part of the cancellated structure are included in the graft, but the inner edge of the bone is left intact to prevent disturbance of muscular attachments that one carried with the graft, and lend an important blood supply that renders the likelihood of failure negligible.

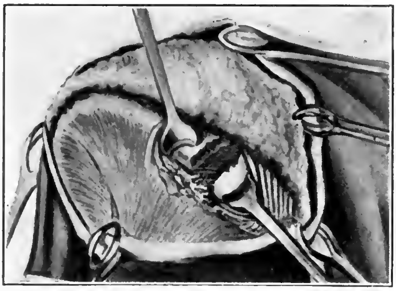


FIG. 452.—Flap doubled up from inside below the jaw and the fractured mandible exposed.

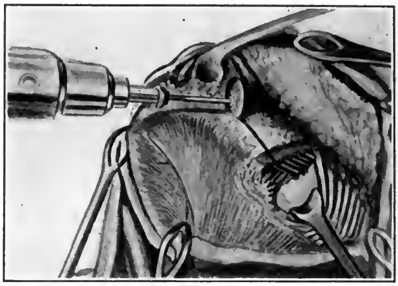


FIG. 453.—Method of suturing the graft from one side of the lower border of the mandible.

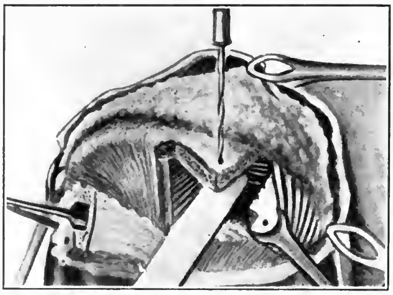


FIG. 454.—Suturing holes for the fixation sutures.

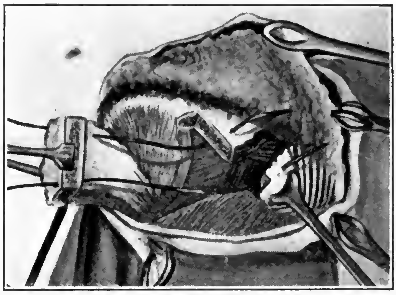


FIG. 455.—The bone graft with attached pedicle ready to be moved into position and sutured.

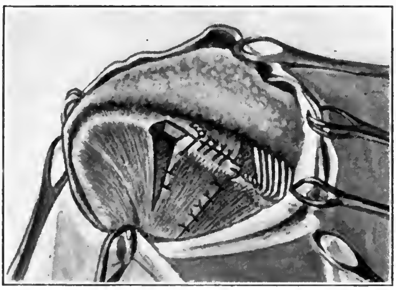


FIG. 456.—Graft and overlying muscles sutured in position.

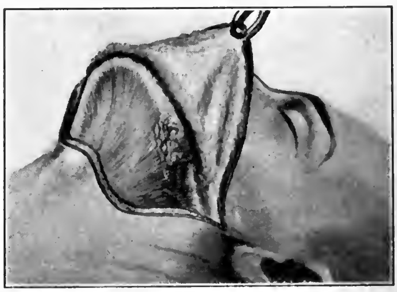


FIG. 457.—Wound closed ready for skin suture.

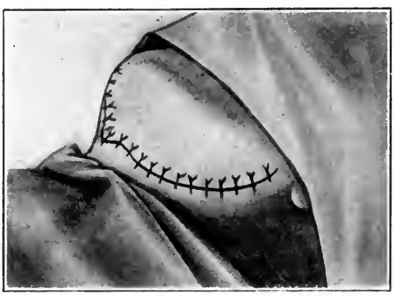


FIG. 458.—Skin flap sutured.

Rib grafts may also be successfully employed to supply lost bone to the mandible, as recommended by Gallie and Robertson, but those who,

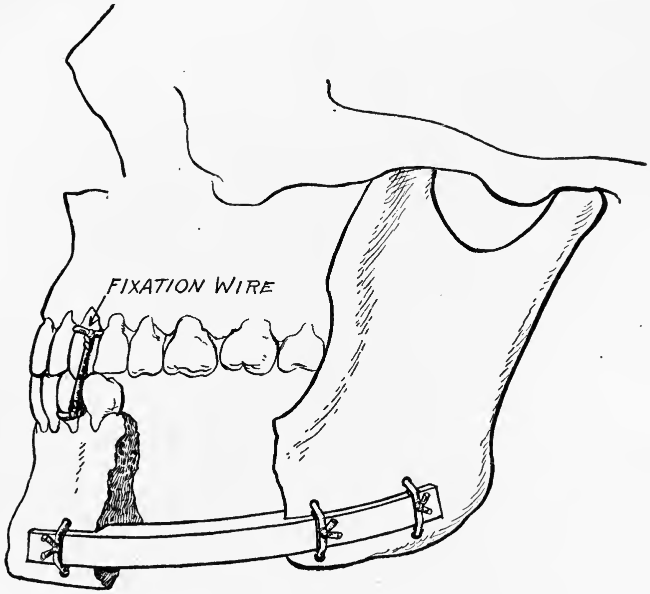


Fig. 459.—Diagram of a fractured lower jaw so badly shattered as to leave a gap where a proper position of the remaining fragments is maintained. This gap can be satisfactorily spanned and the fragments securely united through the inlay method with a graft and gutter produced by twin motor-saws adjusted at the same distances apart, producing an accurate fit of the graft which is held in position by kangaroo-tendon sutures passed through drill holes in jaw fragments. This was a frequent condition in the late war, resulting from the trench warfare. (Albee.)

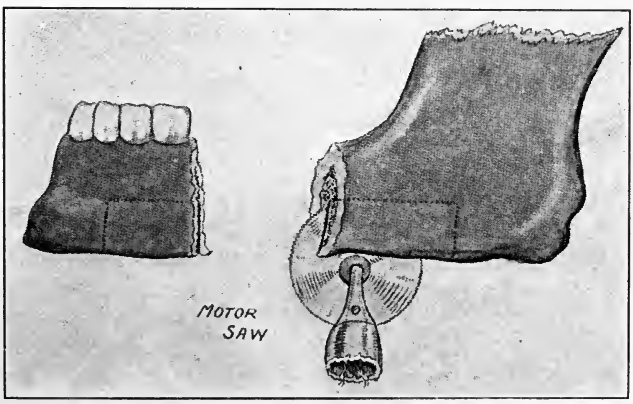


Fig. 460.—Application of the motor-saw in operation for closing gap in mandible produced by gunshot wound. (After Gallie and Robertson.[1])

[1] Transplantation of Bone. By W. E. Gallie, M.D., and D. E. Robertson, M.D., Toronto, Journal of the American Medical Association, April 20, 1918, p. 1134.

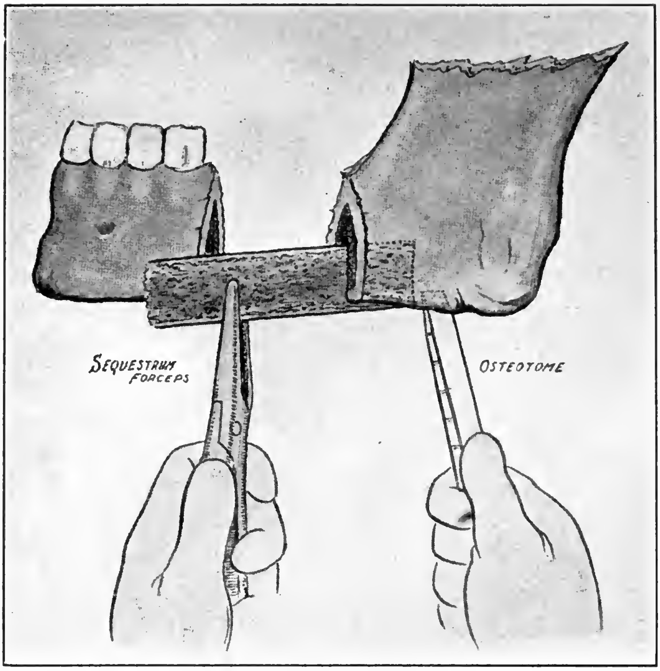


FIG. 461.—Insertion of half of split rim with smooth side toward the mouth cavity. (After Gallie and Robertson.)

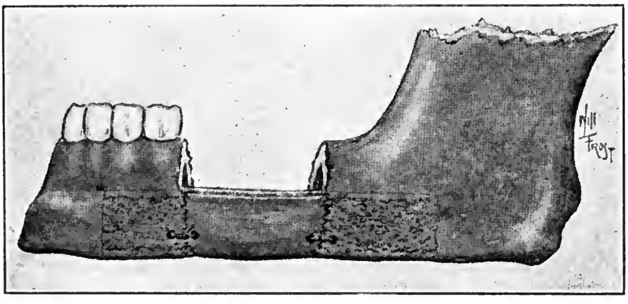


FIG. 462.—Completion of operation by the placing of the other half of the rib in contact with the first half between the ends of the fragments and by the fastening of all in place with kangaroo tendon. (After Gallie and Robertson.)

FIG. 463.—Shrapnel wound destroying outer wall of frontal sinus. Deep depression after healing.

FIG. 464.—Shows result of insertion of rib cartilage transplant.

FIG. 465.—Shows a man with saddle nose.

FIG. 466.—Photograph of the same case after the insertion of a bone and cartilage graft taken from a rib and inserted from the inside of the nose without external scar.

FIG. 467.—Shell fragment wound. Scar that produced a serious case of trismus; was relieved by an operation. Forcing jaws apart unsuccessful until after operation.

FIG. 468.—Shows scar after operation; jaws forced apart. Double result was obtained in this case; disfigurement removed and trismus cured. (Case operated by the author, published by McCauley and Worthley in the Dental Cosmos, May, 1919.)

like the author, are accustomed to employ tibial grafts will doubtless find them preferable under ordinary conditions.

Cartilage Transplants.—Experience appears to prove that bone placed in soft tissue without contact with other bone surfaces quickly becomes

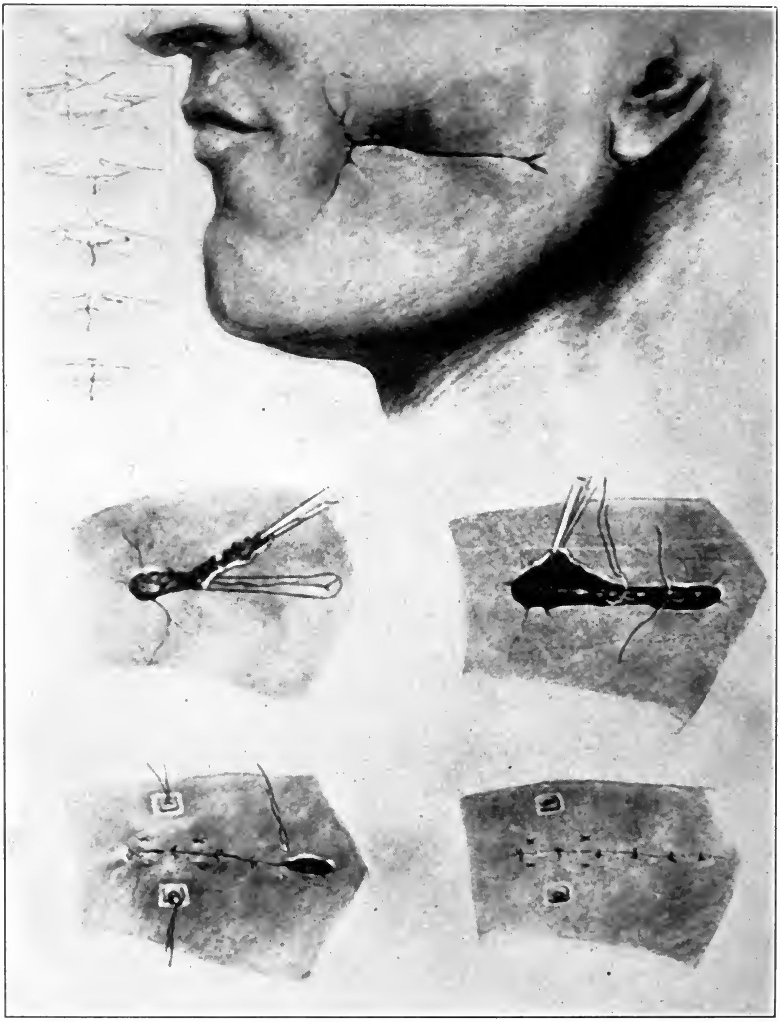


Fig. 469.—Plan of operation as followed by the author in the correction of the case as shown. *a*, illustrates excision of scar; *b*, wide undermining of tissue; *c*, several rows of buried catgut sutures; *d*, tension suture of silkworm gut with metal buttons laid on adhesive to prevent cutting and closure of wound with horsehair and 2000 fine linen.

porous and breaks down. Cartilage receives no benefit from bone contact if used for a graft attached to bone, but when transplanted to situations where it may be surrounded by soft tissue or laid against cartilage it adapts itself readily to the new situations, so that results are eminently satisfactory. Figs. 375, 376, 463, 464, 465 and 466 illustrate the results of cartilage transplants.

Trismus.—Long fixation of the jaws in closed position, as by intermaxillary splints and ligatures, causes a certain amount of stiffness in attempted movement at the temporomandibular articulation, but this usually disappears when jaw movement is restored.

Direct injury to the joint may, of course, cause true ankylosis, but in by far the great majority of jaw fracture cases, when this symptom is present it is due to associated muscular injury, which can be remedied in some instances by continued stretching of the adhesions by forcing the mouth open with gradual increase of the extension or plastic operations to correct the restricting conditions. Fig. 469 illustrates such a case and the method of its correction.

NECROSIS OF THE JAWS.

Necrosis of this bone is due to direct or to indirect infection due to thrombosis.

In necrosis the bone structures are usually more or less simultaneously affected, but osteitis is recognized as affecting the compact portion of the bone, and osteomyelitis an infectious disease involving first the bone marrow and central cellular parts of the bone.

Etiology.—*Hemorrhage under the periosteum* as in scurvy, purpura hemorrhagica, pernicious anemia, and other affections manifested by blood disorders, trauma and infectious diseases, may cause necrosis through formation of blood clots under the periosteum, thus destroying its supporting and protective influences.

Periostitis.—Acute or chronic, simple, non-infective or suppurative periosteal inflammation may also lead to bone inflammations and later to necrosis.

The table on page 650 will serve to give the general surgeon in a simple manner a more comprehensive idea of this subject than would be otherwise possible in the space that is available.

The following etiological classification has been arranged with special reference to necrosis of the jaws.

Pathology.—The pathological changes that lead on from periostitis or osteomyelitis and the destruction of the maxillary bones, to the formation of a line of demarcation between the dead and living bone structures, the formation of a sequestrum and an involucrum, is in no essential respect different from similar processes in any of the other skeletal structures. The only distinguishing pathological change that may occur in the course of this affection in the jaws that cannot be found elsewhere is due to the destruction of tooth pulps whereby the teeth thus devitalized may become persistently active in the continuance and extension of the destructive processes.

In removing large sequestra from the lower jaw, every effort should be made to avoid injury to the periosteum and where large sections of the jaw have been removed, to preserve the form of the jaw by careful packing or by the use of appliances attached to the teeth, if this can be done. Neglect in this regard leads to serious deformity through the contraction of the jaw. But if the parts are kept in position the bone regenerating properties of the periosteum will be found to be almost marvellous in their corrective possibilities. This principle is well illustrated in Figs. 470 and 471.

- Diseases of the teeth and alveolar structure
  - Dento-alveolar abscess
    - Devitalized or infected or gangrenous tooth pulps.
    - Imperfectly filled roots or teeth.
    - Fractured roots of teeth.
    - Implantation, transplantation, and replantation of roots of teeth.
  - Chronic pericementitis.
  - Pyorrhea alveolaris.
  - Pericemental abscess.
  - Ulcerative stomatitis.
  - Gangrenous stomatitis.
  - Gengrenous conditions of the buccal tissues.
  - Traumatism
    - Injury to the periosteum with subsequent infection.
    - Compound fractures of the jaw or of teeth or dislocation of roots of teeth.
    - External blows, or force causing the jaws to strike forcibly together, causing subsequent death and infection of and from tooth pulps.
- Foreign bodies in the tissues.
- Extension of nasal disease.
- Empyema of the maxillary sinus.
- Middle-ear disease, furuncle or other inflammatory affections of the skin and soft tissues of the face.
- Surgical operations upon the maxillary bones.
- Infectious diseases.
  - Exanthemata or eruptive fevers
    - Typhoid fever.
    - Scarlet fever.
    - Measles.
    - Smallpox.
  - Influenza (la grippe)
  - Tuberculosis
  - Syphilis
  - Actinomycosis
  - Glanders
  - Leprosy
- Blood disorders
  - Predisposing conditions
    - Anemia
    - Chlorosis.
  - Leukemia
  - Pernicious anemia
  - Scurvy
  - Septicemia
  - Pyemia.
- Toxic agents
  - Inorganic poisons
    - Mercury
    - Arsenic.
    - Phosphorus.
    - Lead.
    - Corrosive and escharoti acids and alkalies.
  - Organic poisons
    - Vegetable poisons in the form of drugs may lead to necrosis by their direct destructive action upon tissue, or secondarily by causing depleted conditions to the general system, or inducing disease of special organs which may predispose to bone disease, as may also animal poisons, such as bites of venomous reptiles, stings of insects, etc.

In young children, the jaws are filled with erupting teeth and the circulating resistance correspondingly reduced. For this reason children frequently suffer extensive necrosis of the jaws in the course of infections from dental and oral diseases to which they are subject. In these cases it is often difficult to decide whether developing teeth should

FIG. 470.—Face of young woman in whose case nearly all of the lower jaw was removed from the ramus on the left side to the molar region on the right for the removal of the myxoma shown in Fig. 441. Preservation of the periosteum which was permitted on account of the character of the growth and retention of the form of the jaw during healing process resulting in new bone formation so that the girl is now able to wear a lower set of teeth on the newly formed jaw and is only slightly shorter on the left side instead of having the great deformity that would otherwise have resulted.

be retained or removed. Defective teeth that have been almost wholly uncovered by the removal of sequestra of bone surrounding them sometimes retain sufficient vitality to continue the course of their development until new bone is formed and their eruption takes place in due

FIG. 471.—Same girl shown in Fig. 470 before the removal of the myxoma, showing the extent of the jaw involved.

time. On the other hand if such teeth become devitalized the results may be serious. The only safe rule of procedure in these cases is to preserve the dental organs whenever there can be assurance that they are still vital, but to keep them under observation so that if their vitality be lost they may be removed before serious harm has resulted.

Symptoms.—The symptoms of necrosis of the jaws are necessarily modified by the character of the cause. Traumatic injury would be evidenced by inflammation of the periosteum in common with overlying injured parts. Infection from an acute dento-alveolar abscess would present the predominant symptoms of this affection during the early stages. In all the non-traumatic cases there are present the symptoms of acute infectious diseases. These vary greatly according to the severity of the infection, the resistance of the individual, and the conditions governing the actual cause. There may be chills, fever, prostration, temperature ranging from 101° to 105° F., or even higher, with severe local pain and great prostration. The toxemia may be so rapid as to cause delirium, stupor, endocarditis and death, or there may be acute local pain with but slight evidence of general symptoms, or subacute and chronic periostitis, osteomyelitis, or osteitis may lead to the destruction of large areas of bone with almost no serious objective symptoms and complete absence of pain, until in due course there is formation of pus and the final exfoliation of the bone. Tenderness to touch over a more or less considerable area which is marked by redness is usually an early symptom.

Caries of bone, being a slower process, is usually unattended by painful symptoms other than those incident to acute infections, which may be the first cause of the formation of the bone abscess. The most common cause of caries in the maxillary bones is dento-alveolar abscess, which, having become chronic, proceeds slowly with bone disintegration until considerable excavations in the bone have been accomplished.

Diagnosis.—When sequestra of bone have been formed there is usually discharge of pus, which by making pressure upon overlying surface may be seen to exude through several fistulæ. Touched with a probe or suitable instrument, such bone will be found to have lost its velvety feeling and is rough. Usually slight motion of the sequestrum can be detected. In carious conditions due to extensive and long-continued chronic abscesses the external bony wall will usually be found to be extremely thin and yielding to pressure. It is this characteristic which often serves to indicate the existence of a carious area that would not otherwise be suspected. Surrounding bone, not yet fully disintegrated but without normal vitality, is also recognized by its rough, dead feeling. Perhaps in no other part of the body is recognition of the exact cause of necrosis so necessary or difficult. The differentiation of different diseases and forms of infection through which the local disease might have been caused is equally important in all fields of practice, but on account of the multiplicity of cause of diseases of the teeth, and the great variety through which infection might occur, careful distinction is exceedingly necessary.

Treatment of Necrosis and Caries.—In the acute stages, when pain and other symptoms of acute inflammation are present and before nature has had opportunity to complete the process of separation between dead and living bone, treatment is limited to measures which relieve the pain, check the progress of the inflammation, and if possible abort the formation of complete necrosis. Sources of infection or irritation must be brought within control or at least receive appropriate attention. Incision through the overlying tissues and periosteum down to the bone is the best method to check the progress of an acute diffuse suppurative periostitis and will greatly reduce the extent of necrosis in this as in other bones.

When actual disintegration of bone has been accomplished the treatment briefly outlined is as follows:

1. *Correction of the cause.*
2. *Relief of pus.*
3. *Sterilization*, local antiseptic treatment to prevent extension.
4. *Removal of Dead Bone.*—Distinction must be made between necrosis and caries in treatment. No attempt should be made at removing sequestrum until an involucrum has been formed sufficiently strong to maintain the form of the jaw.

The sequestrum or sequestra should be taken out intact if possible. Carious bone must be removed with a surgical or dental engine bur, a chisel, or curette, and all roughened bone borders made smooth. This distinction is very necessary because an attempt to get out a sequestrum of bone with a dental bur would only result in breaking up little particles of bone and forcing them into the tissues, thus leading to continuation instead of relief of the disease. After the sequestrum has been removed the bone borders may be smoothed by the use of a 10 to 25 per cent. solution of sulphuric acid or, better still, with a curette, and all carious bone removed until the smooth, velvety surface of healthful bone can be recognized.

5. *Packing.*—If the cavity in the tissues remaining after the dead bone has been dislodged or cut away, is of such form or situation as to be unfavorable to drainage, then it may be necessary to insert a packing. This is best done with gauze, because cotton is likely to leave threads behind to continue irritation and infection afterward. The gauze should be wrung out of some suitable antiseptic solution, preferably 5 per cent. carbolic acid, and sealed in with collodion or gutta-percha dissolved in chloroform. Once each day this should be changed to avoid infection.

When the wound cavity can be made sufficiently open and saucer-shaped to facilitate natural drainage and prevent lodgment of disadvantageous agents this should be done, and then no packing ought to be used; but the continued holding in the mouth of dioxogen, or any of the well-known suitable germicidal agents, must be depended upon to prevent continuation of the infection. General treatment is often required to overcome the toxic effect of the disease. Iron, quinine, cod-liver oil, and tonics are often valuable.

Diseases such as syphilis, tuberculosis, actinomycosis, leprosy and glanders must each receive its own special treatment as indicated, in addition to the local treatment.

MAJOR OPERATIONS OF THE MOUTH.

By ALBERT J. OCHSNER, M.D.

EPULIS.

Aside from the surgical diseases covered in the preceding chapter we must consider secondary involvement of the cheek, tongue, tonsils, palate and pharynx, following the development of carcinoma of the jaws and especially the form of tumor known as epulis, which begins in the gums from embryonic tissue of a tooth. The condition is only mildly malignant in its early stages, but if only partially removed, or if not removed at all, the condition becomes more and more malignant.

Diagnosis.—The diagnosis has been discussed in the previous chapter. At times, however, the patient comes to the surgeon for the first time with an indurated ulcer of the cheek or tongue or floor of the mouth extending along the margin of the teeth, and the patient gives a history of pain or irritation in the affected area without being able to state at what point the lesion first began.

The edges are irregular, somewhat elevated and usually painful and reddened. They may be quite circumscribed, or they may extend to a greater or less area including any of the surfaces in the mouth.

Differential Diagnosis.—It may be difficult to make a differential diagnosis between epithelioma originating from the mucous membrane or carcinoma originating from embryonic dental tissue or syphilitic ulcer. The latter condition should be confirmed or eliminated by the history together with a Wassermann or Noguchi test. If there is still some doubt, we have seen some striking effects from the use of salvarsan and neosalvarsan. Should the condition improve to a marked extent under this treatment, it should be continued together with the use of mercury and potassium iodide. In case the presence of syphilis has been positively eliminated, it is not important to the patient to determine from which tissue the disease has originated, because the treatment must be the same in either case and the microscopic examination will determine the origin readily when the excision has been made, because the microscopic picture of an epithelioma shows the same type of cells that one finds in the mucous membrane of the mouth as shown in Figs. 472 and 474, while the other shows the form of epithelial cells that one finds in the embryonic tooth, Fig. 475. Under no condition, however, should a small piece of the growth be removed for microscopic examination before operation, because this is followed in many cases by a hopeless metastatic infection, or in an infection of the cervical lymph nodes. In either case, the prognosis is infinitely worse than before this

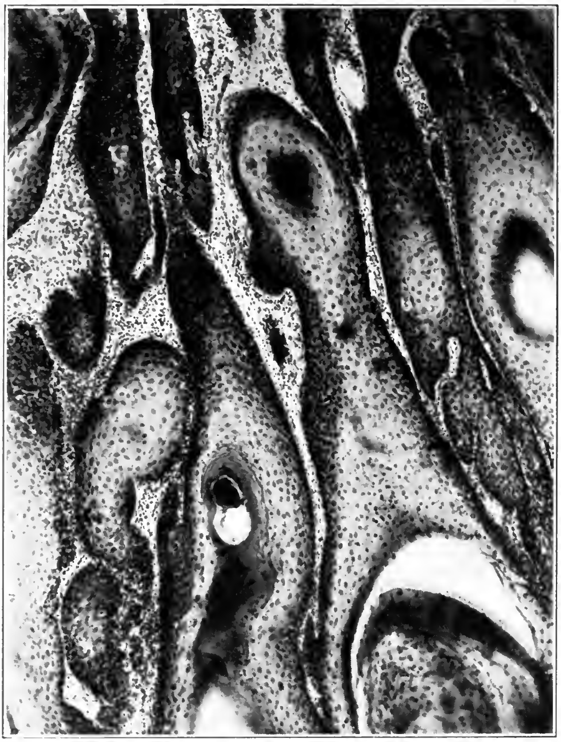


FIG. 472.—Epithelioma of cheek, showing characteristic prickle cells originating from the mucous membrane. × 100.

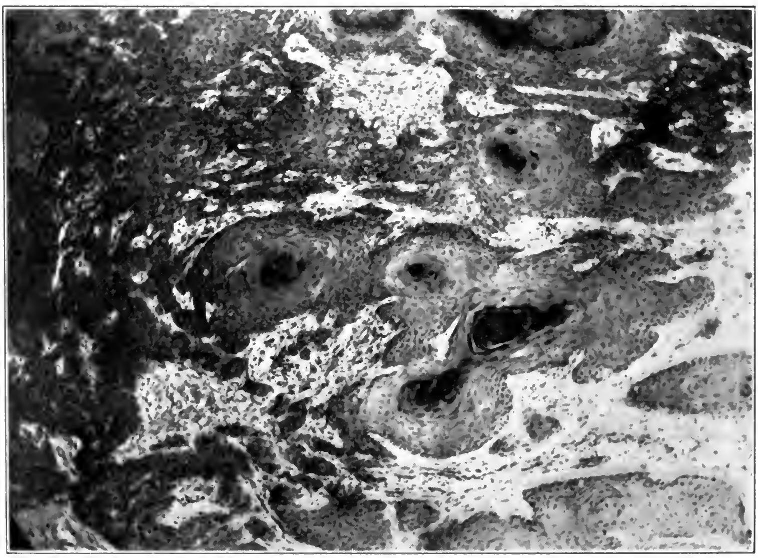


FIG. 473.—Epithelioma of cheek, showing typical pearls of epithelial cells due to process of keratinization. × 100.

useless step was taken, which can at best bring to the surgeon no knowledge which can be of any benefit to the patient, while it is likely

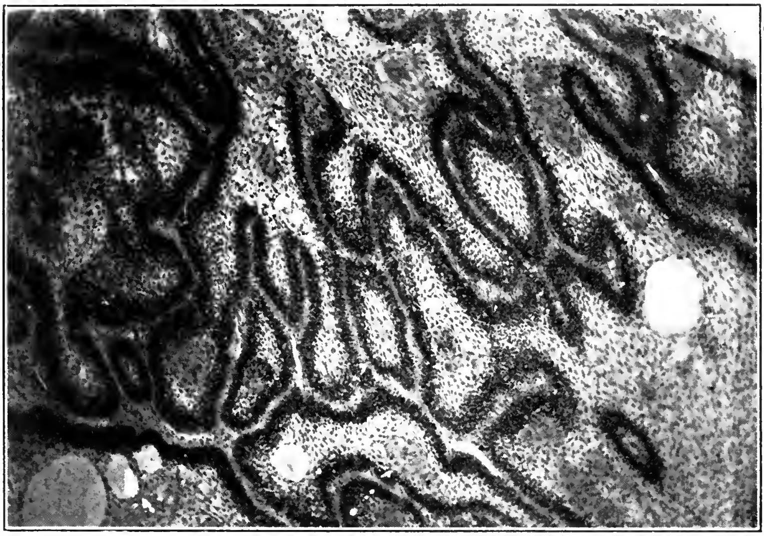


Fig. 474.—Adamantine epithelioma, showing typical structure of growth developing from embryonic structure of tooth. × 100.

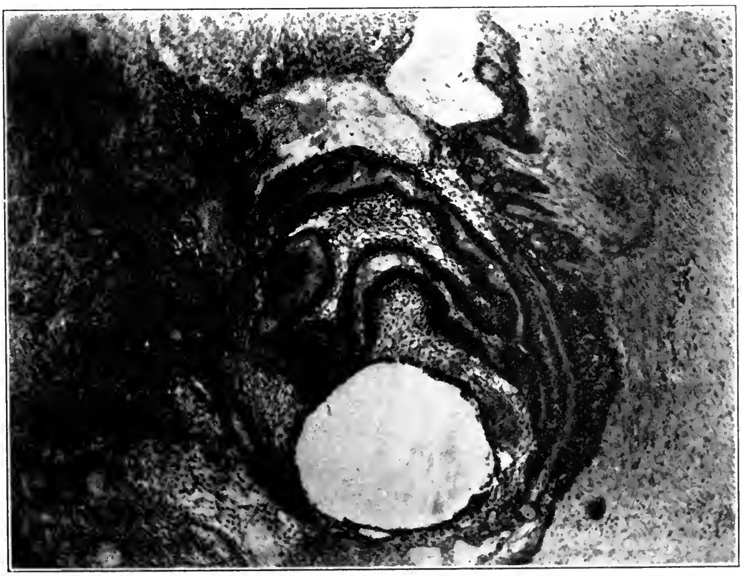


Fig. 475.—Adamantine epithelioma. × 100.

to do the latter an irreparable injury. Unfortunately, the feeling still exists that it is necessary to make a positive scientific diagnosis before the operation by means of microscopic examination, because a number of years ago when only a few surgeons had the facilities for making such examinations, they came to overestimate its value because it placed them in a different class from their competitors and through them the literature was filled with this vicious idea. In many instances, these malignant ulcers are preceded by leukoplakia or psoriasis linguæ.

TUMORS OF THE TONGUE.

Malignant growths of the tongue may occupy areas varying in size and location, making their extirpation difficult or easy. The fundamental principle of making a very extensive excision in removing malignant growths is quite as important in this region as in any other, although it has been pointed out that the blood supply of the tongue as well as the distribution of the lymph spaces, is fairly limited to each lateral half, and that therefore recurrences are quite unlikely, if a malignant growth which is small and circumscribed and located on the lateral edge of the tongue is removed to the midline of the organ. This should apply only, however, to cases in which the growth does not exceed 1 cm. in diameter. In case the growth is more extensive, the entire tongue to a distance of 2 cm. beyond the growth should be removed. If the growth is located upon the upper surface, it is usually not necessary to remove the lymph nodes in the neck.

Methods of Operation.—In case the malignant growth is confined to the anterior half of the tongue, the following method is to be preferred: A chromicized catgut suture is passed through the base of the tongue by means of a curved, round-pointed needle, the tongue being drawn forward, the mouth being held open by means of a gag. Forceps are applied to each end of the suture and the tongue is drawn forward by means of this suture. Then a second suture is placed through the base of the tongue 1 cm. behind the first one. The tongue is then drawn upward toward the roof of the mouth and the lingual artery and veins are exposed by means of an incision through the mucous membrane. These vessels are caught separately between two pairs of forceps, then cut and then ligated. While an assistant pulls the tongue forward by means of the two sutures which were first applied, the surgeon grasps the edge of the tongue and cuts away the organ to a point 2 cm. behind the portion involved, by means of an electric cautery. There will be practically no hemorrhage and the few small vessels which were exposed and which may bleed slightly, are caught by means of hemostatic forceps and ligated. Two chromicized catgut sutures are then applied, grasping the edge of the tongue and following the cut surface at a depth of 1 cm. These are then tied, bringing the two lateral margins together in front. The mucous membrane of the superior and inferior surfaces is then sutured by means of fine chromicized catgut sutures and the two sutures which were first applied are tied loosely and a large pair of hemostatic forceps is applied to the free ends and fastened to the patient's clothing by means of a large safety-pin. Occasionally one of these patients has a spasm which causes him to swallow this stump of the tongue, which may press upon the epiglottis to such an extent as to endanger the patient's life from suffocation.

In case the involvement is so extensive that it cannot be radically removed by this method, it is best to follow the method introduced by Sédillot which has been practiced extensively by Kocher and his pupils. The advantages of this method lie chiefly in the fact that a very extensive operation can be performed practically without the loss of blood and with the greatest thoroughness and the slightest amount of traumatism. This operation is indicated only in case of removal of malignant growths. Non-malignant growths, such as cysts, papillomata, lipomata, tubercles, can be removed by the method described above. It is of course important, in cases of malignant disease of the tongue, to operate immediately upon making the diagnosis, because in early operations the prognosis, so far as permanent cure is concerned, is vastly better than in late operations.

Kocher's Operation for Extensive Involvement of the Tongue.—A preliminary operation is performed, consisting in removing all of the lymph nodes of the neck up to the parotid gland and down to the clavicle and forward along the hyoid bone and lower jaw, including the submaxillary salivary gland together with the lymph nodes surrounding this gland. The anterior facial vein and artery and the external carotid artery are ligated and severed on the side on which the malignant growth is located in the tongue, or on both sides of the malignant growth approaches or extends beyond the middle of the tongue, except that in this case, the external carotid is ligated only on the side on which there is the greater amount of involvement. It is well to perform this operation on one side at one sitting, and then to perform it on the other side a few days later. In all cases whose general condition would indicate that the patient has not a sufficient amount of resistance to withstand an extensive operation, it is well to apply intensive *x*-ray treatments to the side operated upon directly after conclusion of the operation. The ear and face should be protected by means of lead-sheets and the rays should be filtered through an aluminum screen 1 mm. in diameter. The lymph nodes are excised in accordance with the methods described in the chapter on Surgery of the Neck.

After the patient has recovered sufficiently to make the operation for excision of the tongue safe, the following operation should be undertaken. The patient receives a hypodermic injection of $\frac{1}{4}$ grain of morphin and $\frac{1}{100}$ grain of atropin one-half hour before the anesthetic is administered. The patient is then thoroughly anesthetized with ether by the drop method, then a catheter No. 40 French scale is introduced into each nostril a sufficient distance to place its free end opposite the larynx. The two catheters are attached to a Y-shaped, glass tube which in turn is attached by means of a rubber tube to a funnel through which ether may be administered if this is required. The patient is then placed with the head elevated so that the body will lie at an angle of 45 degrees. The resulting anemia of the brain will serve to keep the patient anesthetized without the further use of ether for a period of nearly an hour, which is more than sufficient time to complete the proposed operation. The method is identical with that employed in anesthetizing patients for the operation of thyroidectomy.

A vertical incision is then made through the lip, down over the chin and beyond the edge of the chin for a distance of 4 cm. A Gigli saw is then placed around the inferior maxilla and the latter is sawed through exactly in the median line. By separating the two sections of the jaw, one obtains a splendid approach to the floor of the mouth and the tongue. It is important to preserve without injury the muscles in the floor of the mouth to the greatest possible extent, but this must not be done at the risk of leaving tissues that have been invaded by the malignant growth. All of the invaded tissues are now cut away by means of the electric cautery. There will be practically no hemorrhage, but any bleeding points which may occur, should be caught in forceps and ligated at once. Two cm. of healthy tissue should be removed on each side. In order to prevent the patient from inspiring mucus, it is well to thoroughly cocainize the pharynx before the anesthetic is administered by means of a 4 per cent. cocain spray, and then to place a gauze tampon in the pharynx to prevent the trickling of blood or mucus into the larynx. The preliminary ligation and the position of the patient almost completely prevent the accumulation of blood in this region, and the administration previous to administering the anesthetic of $\frac{1}{100}$ grain of atropin will prevent the secretion of mucus. Both of these points are important in the prevention of postoperative pneumonia. After all of the diseased tissues have been removed, the surfaces are covered to as great an extent as possible with mucous membrane by means of fine chromicized catgut sutures. Any surfaces which cannot be covered are tamponed carefully with iodoform gauze.

During the operation, the manipulations can be greatly facilitated by applying a spreader which will hold the two halves of the jaw as far apart as possible without injuring the ligaments of the joints. Provision is made to prevent swallowing of the stump of the tongue similar to that described above, by means of applying two chromicized catgut sutures through the stump and attaching forceps to the free ends of these sutures. The two halves of the jaw are then brought together; a hole is drilled through each and they are carefully fastened together by means of a silver wire. A drainage tube is placed in the lower angle of the wound and the soft tissues are carefully united by sutures.

After the operation has been completed, the patient should be placed in bed, the top of bed elevated to a height of 40 cm. and a head-rest placed under the head and shoulders of the patient so that the latter will be in a semi-sitting position. Before the operation is undertaken, the teeth should be cleansed, and the mouth washed with peroxid of hydrogen, and it is well to spray the mouth several times each day with oil of eucalyptus for the purpose of cleansing the tongue. A mouth wash of half an ounce of chlorate of potash to the pint of water is also very useful for cleansing the mouth preliminary to the operation. This should be used during the time that elapses between the entrance of the patient to the hospital and the final removal of the tongue. Performing the preliminary operations of ligation and removing the lymph nodes in the neck will postpone the final operation from ten days to two weeks, but if the mouth is carefully cleansed by the methods just described, and if intensive *x*-ray treatment is employed for the neck during this period, it does not seem as though the patient's ultimate results would be harmed by this postponement of the operation.

It seems important to perform the actual removal of the tongue by means of the electric cautery rather than by means of the knife, because there is great danger of transplanting carcinomatous tissue, and if the raw surfaces are made with the electric cautery, this calamity is less likely to occur. In case the carcinoma has extended to the jaw or to the side of the mouth, it is best to remove all of the diseased tissue by means of the actual cautery and to thoroughly cauterize the jaw after extracting the teeth in the region involved. For this purpose ordinary small soldering irons heated in a strong gas flame, are much more effective than the electric cautery or the Paquelin. In case the malignant growth has actually penetrated the jaw, the latter should be resected to a distance of 2 cm. beyond the infected area. It is important in all of these cases to provide for a free external drainage in order to prevent harm from accumulation from wound secretion which might be inspired into the trachea and give rise to pneumonia.

After-treatment.—There is considerable danger from inspiration-pneumonia after these operations. It is difficult for these patients to swallow, and for this reason it is well to pass a catheter into the esophagus through the nose and to administer water and liquid nourishment through this catheter. It is also wise to administer water and concentrated predigested food several times each day by means of proctoclysis. It is most important to keep the head of the patient elevated in a manner in which he can be comfortable and in which the fact of being held in this position will not cause him to become exhausted.

SURGICAL DISEASES OF THE TONSIL.

The diseases of the tonsil requiring surgical operation are hypertrophy due to chronic inflammation, tuberculosis of the tonsils, chronic abscess of the tonsil, and acute abscess. All of these conditions are likely to result from an infection taking place in the tonsil whose anatomical structure has been injured as a result of an inflammatory process occurring during scarlet fever, measles or influenza. Undoubtedly, the physiological function of the tonsil may become so thoroughly impaired as a result of the inflammation accompanying these diseases that the organ is no longer able to protect its owner against infectious material passing over the area it occupies. The crypts on the surface of the tonsil form a convenient lodging place for pathogenic microorganisms which may be placed on the surface in food or in mucus from the posterior nares passing over the surface. The infection with tubercle bacilli and the secondary infection of the lymph nodes will be considered in a subsequent chapter.

Rosenow and others have directed attention to deep infection of the tonsils with a micrococcus which is likely to cause secondary infection in various portions of the body by a selective property for the endothelium covering of joint surfaces especially, and giving rise to a condition ordinarily termed rheumatism, but which is apparently really a form of sepsis, which will be considered elsewhere. The acute infections of the tonsils may be caused by any one of a number of microörganisms the most common of which are, the pneumococcus, the various streptococci, and staphylococci, but the infection is commonly mixed.

If an abscess forms, producing what is commonly known as quinsy sore throat, an incision should be made through the anterior surface of the tonsil in order to permit the pus to escape. After this, hot antiseptic gargle should be used until the acute infection has subsided, and then the tonsil should be removed. This should also be done in case of chronic infection resulting in hypertrophy or the presence of deep-seated small abscesses.

Tonsillectomy.—This operation can be performed with equally good results by a number of different methods. In children it is best to perform the operation under ether or gas anesthesia; in adults it is usually best to spray the pharynx with a 4 per cent. cocain for a period of five minutes and then to inject one-half of 1 per cent. of novocain to which two drops to each 10 c.c. of 1 to 1000 solution of adrenalin chlorid has been added. It is well to use from 2 to 5 c.c. of this mixture for injecting each tonsil, which will cause it to protrude. After waiting several minutes, in order that the remedy may have the desired effect, the upper pole of the tonsil is grasped by means of a pair of fine-toothed forceps and the mucous membrane is cut with curved scissors or a fine scalpel preferably curved on its flat surface about the base of the tonsil which is then lifted forward and a wire snare is placed around its base and this is tightened slowly so as to cut off the tonsil within its base. If the surgeon has acquired much experience in the use of a tonsillotome, the same result may be obtained in a much shorter time by the application of one of these instruments, provided the tonsil is drawn forward sufficiently to insure its complete removal. In children it is sometimes desirable to cut off the outer half of the tonsil by means of a tonsillotome, and then to enucleate what is left of the tonsil down to the capsule by means of the index finger, because in this way the entire diseased portion of the tonsil can be removed and the loss of blood can be minimized.

Malignant Growths of the Tonsil.—Occasionally one encounters an epithelioma of the tonsil in its early stages. In this case, the operation that was first described above for the removal of infected tonsils can be employed in the removal of a tonsil containing a small malignant growth, but in place of using scissors or scalpel it is best to use an electric cautery. In case the carcinoma is advanced, it is usually not possible to perform an operation which will result in a permanent cure, but if this seems possible or advisable, the operation which has been described for the removal of the tongue can be employed for the removal of cancer of the tonsil, with the exception that the lymphatics of the neck will have to be removed only on one side. It should, however, be remembered that when the disease has advanced sufficiently far to make this extensive operation necessary, it is almost never possible to obtain permanent cure.

In this extensive operation, it is wise to sever all of the tissues by means of the electric cautery. It is also wise to administer extensive *x*-ray treatments before and after the removal of these growths. Recently remarkedly good results have been obtained by the use of radium, using the cross-fire method of placing a tube containing radium on each side of the neck.

Carcinoma of Other Portions Communicating with the Mouth.—In the removal of malignant growths from other portions communicating with the mouth, such as the pharynx, the posterior nares, the uvula, or the pillars of the fauces, the same principle must be employed as in the operations just described. It is important to secure free access to the surface to be treated, and to make a very free removal of the diseased tissues together with at least 2 cm. of the surrounding tissues. It is wise to remove all communicative lymph nodes in the manner decribed above, and also to make preliminary ligations in the same manner and to employ after-treatment with the *x*-ray. In all of these cases, it is wise to perform the operation with the body placed at an angle of 45 degrees, with the head elevated, and to use the form of anesthesia described above.

It is possible to obtain a very good view of the cavity of the mouth and pharynx through a transverse incision recommended by Roser, extending from the angle of the mouth directly backward in the direction of the angle of the jaw, extending to the edge of the masseter muscle. By extending the incision in the skin a little further back, the edge of the masseter muscle may be retracted sufficiently to increase the opening quite considerably. Stenson's duct remains entirely above this incision and need not be considered in making the incision, but in applying deep sutures in closing the wound, one must bear the location of this structure in mind in order not to perforate it with the needle or surround it with the sutures. The maxillary artery should be clamped with two pairs of forceps and then cut and ligated in order that the field of operation may not be traumatized unnecessarily in attempting to stop the fierce hemorrhage which is sure to occur if the vessel is severed carelessly.

There will be no interference with the nerves controlling the facial expression if the above directions are followed. The scar is always somewhat disfiguring, but much can be done to reduce this by limiting the traumatism to the slightest possible amount and by taking great care in closing the wound by first applying from two to four silkworm-gut sutures grasping the entire thickness of the cheek down to, but not through the mucous membrane, then suturing the latter with fine interrupted chromicized catgut sutures, then uniting the layer between the mucous membrane of the cheek with fine eight-day catgut, and then uniting the skin with horsehair sutures drawn just tightly enough to secure an accurate coaptation of the edges, but not sufficiently tight to cause even the slightest degree of pressure necrosis. The silkworm sutures which were first applied remain untied until all of the other sutures have been applied and then they are tied over all, but also very loosely to provide for the edema which will appear. One may tie these sutures over a piece of gutta percha tissue folded upon itself, or one of the ends may be drawn through a piece of fine rubber tubing 0.5 cm. long in order to prevent marking of the skin.

The horsehair sutures should be removed on the third or fourth day, the silkworm-gut sutures from the sixth to the tenth day. The longer these sutures remain, the better it will be provided they do not cut into the skin.

This incision is less formidable than Sédillot's described above, but it gives access to only one side of the cavity of the mouth and the resulting deformity as a rule is more noticeable because every motion of the face pulls upon the resulting scar and directs attention to its existence. Many of these patients are very sensitive concerning the fact that they have had a malignant growth removed, and it is consequently wise to discuss the matter of the scar with the patient before the operation is undertaken.

In case the patient cannot decide upon either of these two methods in a case in which a radical operation cannot be performed through the mouth, the following plan may be adopted, although it is not nearly so convenient for the surgeon and somewhat more dangerous to the patient.

If this method is chosen, it is even more important to have every possible source of infection from the mouth eliminated, than if any one of the other methods is chosen, because this method contemplates a direct communication between the mouth and the wound in the neck.

It is wise to have the mouth disinfected as thoroughly as possible by the use of peroxide of hydrogen, a weak solution of formaldehyde, a saturated solution of chlorate of potash in water, spraying with eucalyptus oil, and then to have all of the teeth mechanically cleaned by a dentist and all of the infected roots extracted and the gums repeatedly swabbed with compound tincture of iodin for several days before the first step of this operation is undertaken. Too much stress cannot be laid upon these steps which can usually be carried out while the patient is considering the proposed operation.

During this, the neck should be exposed to daily x-ray exposures. Having decided upon this operation and having accomplished the preliminary disinfection of the mouth, ether is administered according to the method described in the chapter on Surgery of the Thyroid Gland, page 771.

The patient is placed in an inverted Trendelenburg position with the head of the bed elevated 45°. If the patient is thoroughly anesthetized with ether by the drop method in the horizontal position before being placed in this inverted Trendelenburg position, the resulting anemia of the brain will keep him sufficiently under the influence of the ether to enable the surgeon to complete the operation without the further use of ether. The $\frac{1}{4}$ grain of morphin which was given hypodermically before the operation was begun will reduce the patient's sensitiveness greatly and the $\frac{1}{100}$ grain of atropin will reduce the secretion of mucous in the mouth and pharynx. By following this plan, one can avoid the preliminary tracheotomy which has been recommended by many surgeons for the purpose of giving the anesthetic through the tracheotomy cannula. It is also very much to be preferred to all of the intratracheal methods of administering anesthetics which have been recommended.

It is an excellent plan to spray the mouth and pharynx thoroughly with a 4 per cent. solution of cocain for a period of about five minutes before the administration of ether is begun.

Technic of Operation.—An incision is made from the tip of the mastoid process to the sternum along the sternocleidomastoid muscle. A second incision is made 2 cm. below the edge of the jaw and parallel with this from the first incision to a point 2 cm. beyond the symphysis of the jaw, in order that all of the submental lymph nodes may be removed together with the submaxillary lymph nodes on the affected side. If the growth is located in the middle portion of the tongue or the floor of the mouth, an incision must be made along the anterior border of the sternocleidomastoid muscle of the opposite side as well. If the patient is in good physical condition, this may be done at the same sitting, otherwise the second operation should be postponed until the patient has regained a sufficient amount of strength to make this step safe, which usually requires less than one week. During this interval, daily x-ray exposures should be made to both sides of the neck. From these incisions all of the lymph nodes that may have become invaded can be removed, and the lingual artery and vein may each be clamped separately with two pairs of hemostatic forceps, the former preferably below and to the inside, the latter to the outside of the hypoglossal muscle.

After removing all of the lymph nodes and ligating the vessels, the entire surface is covered with gauze pads wrung out of hot water at least 160° F. in order thoroughly to cleanse the surface, and to expose any fragment containing infected cells to a temperature which is not sufficient to destroy the normal tissues, but is supposed to be sufficiently high to disinfect tissues containing a slight amount of carcinoma tissue. We have made the dissection of the neck with the fine blade of an electric cautery a number of times. This does not seem to interfere with the healing of the wound and it has seemed to protect the patient against grafting of carcinoma tissue with the scalpel. Our results are not old enough, nor have we made use of the cautery in a sufficient number of cases to make it proper for us to place too much emphasis upon this feature of the operation.

The lymph nodes in and about the submaxillary salivary glands and those located in the angle formed by the facial vein with the deep jugular are most likely to be infected, but it is important to follow the deep jugular vein throughout its course in order that no infected lymph nodes may be overlooked.

After all of the glands in the entire field of operation have been removed and the surface exposed to the hot pads for five minutes, the wound along the edge of the sternocleidomastoid muscle is carefully sutured. The space below the jaw and chin is packed with gauze and the edges of the skin are approximated within a distance of 1 cm. of each other by means of interrupted horsehair sutures for the purpose of preventing the skin from curling up during the time intervening between this primary and the secondary operation which is to follow after a period of one to two weeks, according to the condition of the patient. By this time the entire surface will be so thoroughly covered with granulations that a secondary infection from the secretions from the mouth will be prevented following the second operation.

During the interval between the first and second operations the neck should be subjected to daily *x*-ray exposures, and the cavity of the mouth should be disinfected repeatedly each day.

Technic of the Second Operation.—It is well to administer a hypodermic injection of $\frac{1}{4}$ grain of morphin and $\frac{1}{100}$ grain of atropin and then to consume the half hour following in thoroughly cleansing and disinfecting the cavity of the mouth, then spraying the cavity for five minutes with a 5 per cent. solution of cocain and then to administer ether according to the method described above.

After thoroughly anesthetizing the patient in the horizontal position, a catheter of suitable size, just large enough to fill the nostril, is introduced into the pharynx through each nostril. These catheters are attached to a Y-shaped glass tube whose third branch is united with a glass funnel by means of a rubber tube. This arrangement will enable the patient to breathe comfortably, and in case the operation should be continued so long that additional anesthesia may be required, this can be readily administered by placing a small piece of gauze in the funnel and saturating this with ether by the drop method.

The wound beneath the jaw is then opened by cutting the provisional sutures, and the cavity of the mouth is opened through the space formerly occupied by the gauze packing. It is best to do this with the electric cautery or with the Paquelin.

The malignant growth together with the surrounding tissue for a distance of 2 cm. is then removed with the cautery. There will be very little hemorrhage, which can be easily controlled. It is usually most convenient to perform a part of the operation through the mouth and a part through the wound in the jaw.

So far as possible, the raw surfaces are covered by suturing and the remaining surfaces are tamponed with gauze. The space underneath the jaw is again tamponed and the wound edges are approximated as in the primary operation. If possible, the cavity into the mouth is closed by means of catgut sutures, but if this is not possible it is packed with gauze continuous with the packing in the primary wound. Iodoform gauze seems most satisfactory for this purpose.

The patient is placed in bed in the sitting posture, which seems to prevent inspiration pneumonia as well as hypostatic pneumonia. Liquid nourishment, as concentrated as possible in composition, is administered through a catheter inserted into the esophagus through the nose. The mouth is sprayed with oil of eucalyptus every three hours.

After the first week the mouth is cleansed and disinfected with peroxide of hydrogen and a saturated solution of chlorate of potash and the spray with oil of eucalyptus is continued.

After a week the packing in the submaxillary space may be removed and the suture may be tightened to produce an accurate coaptation of the skin. It is well to leave a small drain in the lower angle of the wound for some days.

Involvement of the Jaw.—Whatever operation may be chosen, it is always important to determine whether there has been any involvement of the jaw.

In case any portion of the jaw has been attacked by the carcinoma, the entire surface involved should be destroyed by the application of the actual cautery, which should be held in contact with the bone sufficiently long to insure the deep destruction of the infected tissue over the entire portion apparently involved and a distance of 2 cm. beyond this. This can be done most effectively by the use of small soldering irons heated to red heat in a strong gas flame most conveniently produced by a cluster of Bunsen burners. The sequestrum formed in this manner is exfoliated later, leaving a sufficient amount of healthy bone to support the remainder of the jaw. This method seems quite as thorough as the complete removal of a portion of the jaw, and it leaves the patient in a very much more satisfactory condition, but the cautery must be very thoroughly applied and for a sufficient length of time to expose the deep tissues to a high degree of heat. It is important to use a cautery iron sufficiently large to carry a high degree of heat for a long time. We have not succeeded in finding an electric cautery sufficiently heavy to do this. A very large blade of a Paquelin cautery will suffice, but there is no other cautery that quite equals the soldering iron.

SURGERY OF THE NECK.

By MARTIN B. TINKER, M.D.

WRY-NECK OR CAPUT OBSTIPUM OR TORTICOLLIS.

Simple Wry-neck.—Two distinct varieties of wry-neck have to be considered: The ordinary form affecting the muscles chiefly and usually occurring congenitally or among young children. The spasmodic form in which there are forcible cramp-like contractions of the muscles, frequently attributed to nervous causes.

Diagnosis.—The appearance of the patient is so characteristic that there is little difficulty in diagnosis. The head is rotated and drawn down by the sternomastoid muscle of the affected side. This gives rise to curvature of the cervical spine with its concavity toward the affected side, and a compensatory curvature of the thoracic and lumbar vertebræ. There is also lordosis, the curvature of the cervical vertebræ being markedly forward. The shoulder of the affected side is elevated and in long standing cases the bones of the head and face are deformed as result of pressure. This deformity of the face most frequently occurs with growing children. The affected side of the face is broader and lower, the sound side narrower and longer, and there is more or less atrophy from disuse of the soft parts as well as the bony deformity from pressure. Probably the most striking feature in the condition is the rigidity of the sternomastoid muscle which is considerably shortened and runs in almost vertical direction from its attachment at the clavicle to the mastoid process. The rigidity of the muscle is difficult or impossible to overcome without anesthesia in many cases. The sternal portion is usually more affected than the clavicular portion. Frequently many neighboring muscles as well as the sternomastoid are affected. Reference to Fig. 476 showing the characteristic position of the head and neck will be more valuable than any description however extended. Having once seen the condition it can hardly be mistaken.

In the differential diagnosis we have to consider a number of conditions affecting the bones and soft parts which give a somewhat similar position of the head, although the position is not really characteristic of wry-neck in any of these cases. Tuberculosis of the cervical spine may cause somewhat similar malposition, but it would usually be readily possible to locate the diseased vertebra by examination of the cervical spine. In such cases there would be decided pain and tenderness on pressure, or on moving the head, which would be relieved by rest in bed. Wry-neck is seldom, if ever, painful.

Deep seated abscesses of the neck frequently caused by tuberculosis of the deep cervical glands may cause muscular contraction and may result in some cicatricial contraction, but such deformity is not usually extreme or characteristic and the history would lead to a clear diagnosis in most cases. Not infrequently such infectious processes follow typhoid fever, or scarlet fever; less frequently measles or diphtheria. Arthritis deformans may affect the cervical spine, but there is a long and characteristic history with involvement of other joints. Cicatricial contractions of the skin and subcutaneous tissue also draw the head to one side and sometimes produce somewhat similar deformity, but there is usually a history of severe burn with ulceration and resulting contracture or extensive ulceration from carbuncle or other infection of the neck; occasionally from tuberculosis or syphilis. The

FIG. 476.—Congenital wry-neck. (de Quervain.)

painful stiff neck which sometimes results from sleeping in a draft in rare cases may result in more or less permanent deformity. Such myositis would usually yield readily to hot compresses, massage, and suitable medical treatment, and would not be likely to be mistaken for the real permanent wry-neck. In case syphilitic or tuberculous involvement were suspected, whether of bone, muscles or of the skin and superficial fascia, the Wassermann or tuberculin test might be of value.

Treatment.—In recent years a considerable number of cases affecting nursing children have been successfully treated without operation by various methods of orthopedic surgery. With these facts before us it would probably be unjustifiable to operate in the case of infants or children under two years of age without first giving orthopedic measures a thorough trial. If the case is taken immediately in infants as soon as the diagnosis is established, the results are usually good. The treatment consists at first in bringing the head and neck into over-corrected position and holding it there a short time, the manipulation being repeated a number of times daily. Generally in such young children a very moderate amount of force is necessary. With this is given light massage, and later on sometimes an extension apparatus is applied with counterextension on the diseased shoulder. Various forms of fixation dressings also may be applied, sometimes a plaster-of-Paris bandage holding the head as well as the neck and shoulders, or in less severe cases a molded paper or leather stock about the neck. In these very young children, the little used silicate of sodium bandage would answer every purpose and deserves to be more generally used. Liquid glass for such bandages is easily obtained and inexpensive. It is also very easy to apply, not as sloppy as plaster of Paris, and very much lighter and more comfortable to wear.

Lorenz's method of forcible replacement which results in tearing the muscles in most cases should be mentioned only to be condemned, as the tearing of bloodvessels and nerves which has resulted in many cases has sometimes been fatal or given rise to permanent paralysis.

Operative Measures.—*Subcutaneous division of the sternomastoid muscle* was formerly extensively used in the treatment of wry-neck, but is now practically abandoned. Every one who has seen, in the open operation, the extensive adhesions usually present in these cases and the danger of injury to the jugular vein which the sternomastoid muscle directly overlies, would be hard to convince of the justification of this method. In pre-antiseptic days when the method was introduced it may have had advantages, but at the present when the cosmetic affect of a small scar is the only apparent advantage, it would seem to have little to recommend it.

Open Division of the Sternomastoid Muscle.—Because of extensive adhesions usually present in these cases and the rigidity of the muscles of the neck, a general anesthetic is advisable, sufficient to give muscular relaxation. The patient may be placed with a small sand-bag between the shoulders in order to make the muscles more prominent and the shoulder of the affected side is less in the way if drawn down by an assistant. We believe that a more liberal incision than is usually recommended has decided advantages, especially in cases with extensive involvement. It is of some advantage to place the skin and muscle incision at different levels so that there is not direct attachment of the scar to the deeper parts of the wound. If a low transverse incision is used which comes in line with the normal folds and wrinkles of the skin, the scar is usually insignificant. The most satisfactory transverse incision is that employed by Robert Jones, consisting of an incision parallel with and just superior to the clavicle and extending from the middle of the sternum to a point just beyond the middle of the clavicle. Through this incision the sternal as well as the clavicular attachment of the sternocleidomastoid muscle can be severed, care being taken to cut all the fibers so that when the head is placed in the overcorrected position, the muscle has lost its tension entirely. The results following this operation are most satisfactory. In case the entire muscle is unusually thick and prominent, it may be preferable to make an incision along the anterior border of the sternomastoid muscle and to dissect this muscle free from all of its attachments. The muscle is then divided obliquely or split vertically and cut out above and below as suggested by Keen. The head is placed in the overcorrected position and the distal ends of the split muscle are sutured by means of a few fine catgut sutures. If these methods of muscle plastic are used, special care should be taken to draw the head as far into the overcorrected position as is possible before suturing the muscle. It is usually considered inadvisable to suture the muscle ends in the extreme or long-standing cases. The after-treatment is of a good deal of importance in many cases. As a rule it is wiser to keep the head in the overcorrected position for from one to three months after operation by the use of some retention bandage. If plaster of Paris is used, especial attention should be given to padding so as to avoid pressure discomforts and damage to the soft parts. Exercises bringing the head into the overcorrected position are also of value. With older patients, especially those who are working at a desk, it is sometimes desirable to have a mirror before them so that they may be reminded to keep the head in proper position. This effort should also be aided by reminders from teachers and parents.

Fig. 477.—Body and head cast applied to overcorrect deformity after operation in congenital torticollis. (Wullstein.)

The operations above described are all that are needed for cure in the vast majority of simple cases of wry-neck. Various modifications of these methods have been suggested. Lange advises division of the muscle just below the mastoid process and reports good results, but it would seem that there would be more disfigurement without any advantage in this method. Mikulicz advised complete excision of the sternomastoid muscle in extreme cases and others have modified this procedure to the removal of the lower segment of the muscle as far as the spinal accessory nerve. The results of simple division are so satisfactory that the Mikulicz method might perhaps be limited to the occasional recurrences, especially when of extreme form.

Spasmodic Torticollis or Wry-neck.—In this condition the head is rotated into the wry-neck position with greater or less frequency. In certain cases the rotation is combined with a drawing backward, sometimes spoken of as retrocollis.

Diagnosis.—As with simple wry-neck there is usually little difficulty in diagnosis. The cramp-like muscular contractions, which in some cases are of great severity, draw the head into characteristic position which is not seen in any other disease. The contractions cease during sleep or when the patient is under general anesthesia. In the extreme cases it is impossible to hold the head in normal position by the hands or to retain it by any ordinary form of fixation dressing.

Treatment.—As the disease occurs most often among patients with decidedly neurotic tendencies, the nerves supplying the contracted muscles were formerly attacked in the surgical treatment of this condition. In later years operation upon the muscles has come into more general favor.

Nerve stretching, usually limited to the spinal accessory nerve, did not give permanent results and has been practically abandoned.

Division of the spinal accessory nerve may be tried in early cases in which the symptoms are not severe, and sometimes gives permanent results. For division of this nerve a transverse incision may be made, beginning just below the mastoid process and extending downward and forward toward the angle of the jaw. Beneath the skin the external jugular vein and the large auricular nerve should be avoided. The sternomastoid muscle is retracted backward, being careful to avoid the internal jugular vein which lies just beneath it. The spinal accessory nerve runs downward and backward into the sternomastoid muscle, passing in front of the transverse process of the atlas, which is usually so much more prominent than the other transverse processes as to be readily distinguished. The occipital artery usually crosses the nerve, running backward toward the mastoid process, and the lowest branch of the facial nerve, which supplies the muscles of the chin and outer angle of the mouth, is sometimes encountered and injured unless care is taken. The spinal accessory nerve is covered by the digastric muscle above and is accompanied by a small arterial branch from the external carotid. Some prefer to expose the nerve by incision along the posterior border of the sternomastoid muscle. As the posterior border of the muscle is dissected, the division of the spinal accessory nerve which supplies the trapezius muscle is usually readily exposed, and may be used as a guide to the division which supplies the sternomastoid.

Division of the upper three or four cervical nerves as practiced by Keen and others sometimes gives a cure in the more obstinate cases. The fact that this method permanently paralyzes the muscles involved and has given permanent results in less than half the cases reported by various operators has led Kocher and others to prefer operation upon the rotating muscles of the neck.

Division of the Rotating Muscles.—This is sometimes known as Kocher's operation for spasmodic wry-neck and has given such satisfactory results in the hands of a number of experienced surgeons (approximately 85 per cent. of cures or decided improvement), that it may be considered the operation of choice in the more extreme and

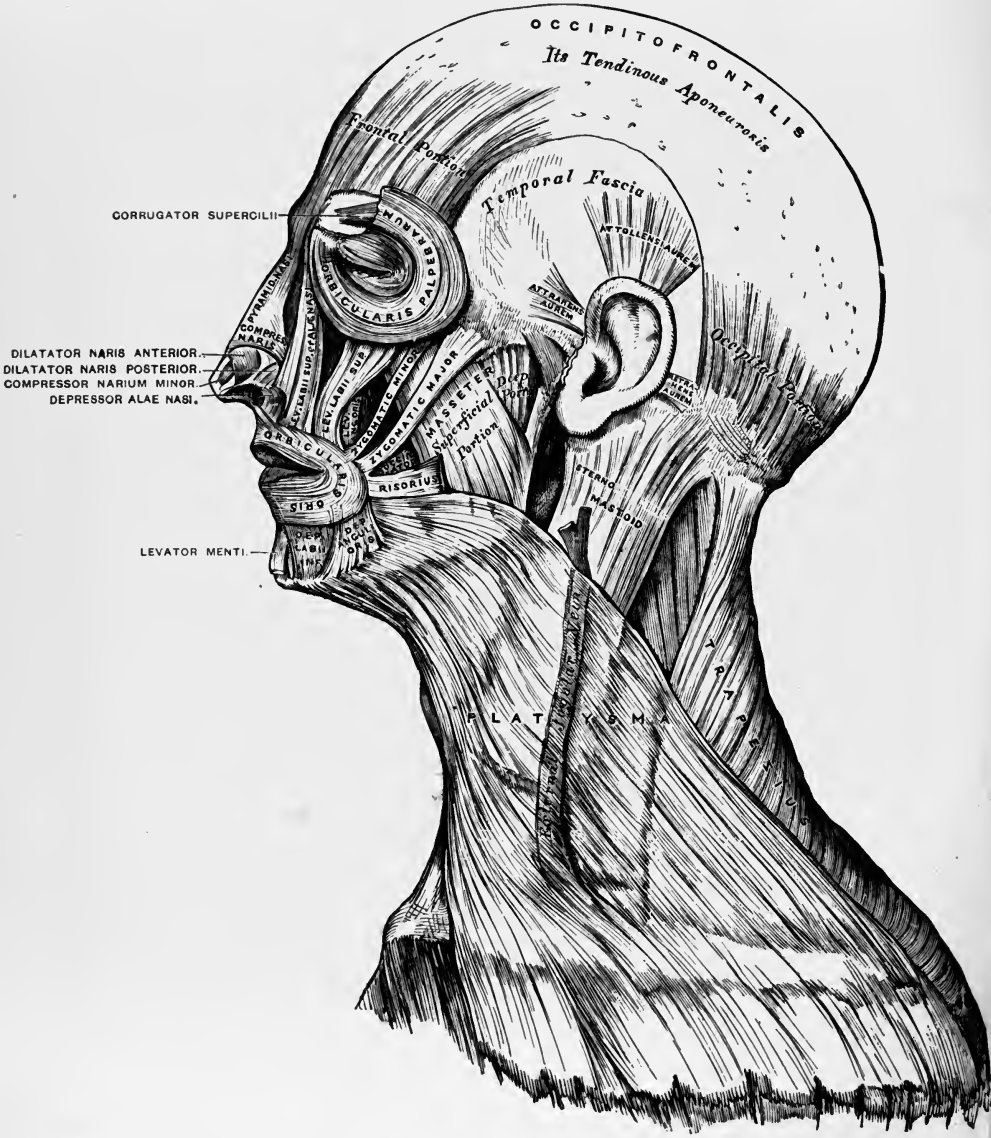


FIG. 478.—Superficial muscles of the neck. (Gray.)

obstinate cases. Kocher's description of this operation is sufficiently concise and clear as a guide for experienced surgeons, but a careful study of the anatomy of the muscles of the neck, if possible supplemented by dissection, will prove of great value to any one planning to undertake the operation and desiring the best results. The anatomy of this locality is so unfamiliar to many, even among active surgeons, that, without such special study, it is hardly possible to perform the operation satisfactorily. Kocher advises an incision beginning two finger breadths below the occipital protuberance and extending obliquely downward and forward to the anterior border of the sterno-mastoid muscle. The splenius capitis muscle is divided its entire breadth, being careful not to go too near its insertion in order to avoid

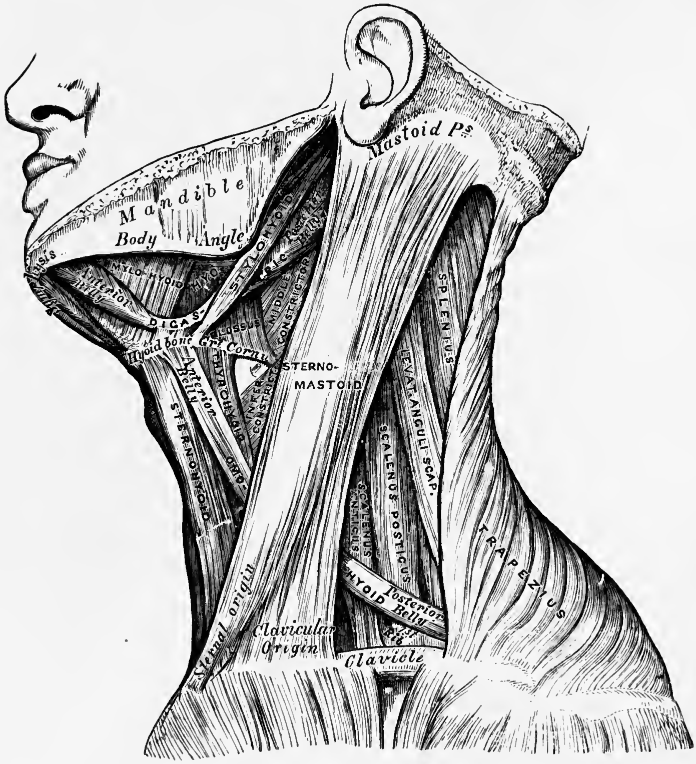


FIG. 479.—Muscles of the neck. Lateral view. (Gray.)

the minor occipital nerve and the occipital artery. Laterally from the splenius capitis the longissimus capitis (better known to many as the trachelomastoid) is divided just below its insertion into the mastoid process, and lying next this muscle the attachments of the splenius cervicis to the transverse processes of the first and second cervical vertebræ are divided. Next the lateral edge of the thick semispinalis capitis (complexus) is drawn toward the median line with retractors and divided, for under this muscle lies one of the most important of the rotating muscles, the obliquus capitis inferior. This muscle is attached to two spinous processes and extends to be inserted into the transverse process of the atlas. Kocher emphasizes the thorough division of this muscle, avoiding at the same time injury of the major occipital, a sensory nerve which winds around the lateral border of the muscle. This operation is complicated and difficult, but with careful study it can be correctly carried out by any man thoroughly familiar with surgery, and it has given most excellent results in the hands of a number of experienced surgeons. In case the extensor muscles are also involved (retrocollis), still more extensive operation is necessary. Not

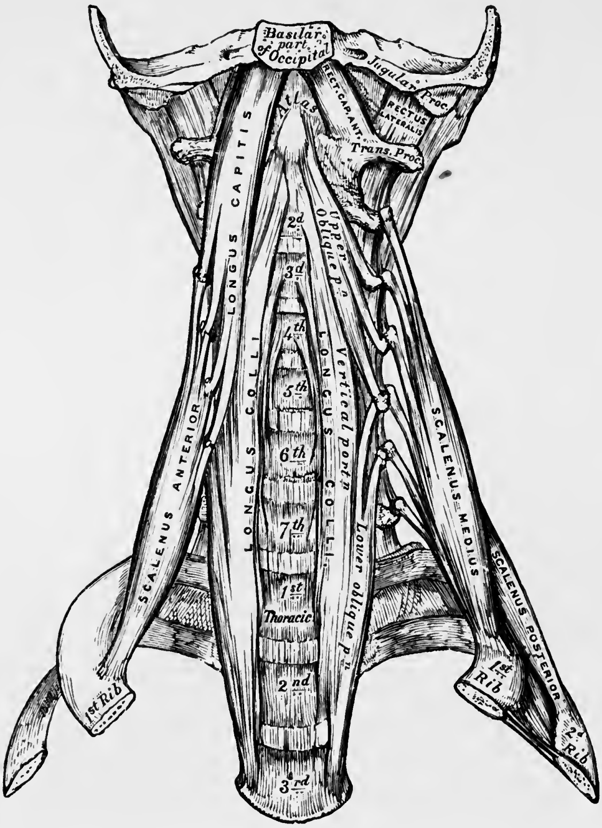


FIG. 480.—The anterior vertebral muscles of the neck. (Gray.)

only the trapezius and complexus and also the attachments of the semispinalis cervicis to the spinous processes of the two cervical vertebræ, but also the smaller muscles of the neck, the rectus capitis major and minor, and the superior oblique must be divided, because of their connection with the skin of the back of the neck. In certain cases both sides must be operated upon. In order to avoid disfiguring sinking in of the scar at the back of the neck, Kocher suggests muscle transplantation, attaching the stump of the longissimus capitis to the proximal stump of the trapezius. In order to do this both stumps must be left long. A plaster-of-Paris dressing is then applied. There has been such a large percentage of relapses or complete failures from poorly planned, indiscriminate cutting of the muscles of the neck for the relief of spasmodic wry-neck, that Kocher's admirable method deserves careful attention.

CONGENITAL FISTULÆ OF THE NECK.

Median and lateral fistulæ are seen which arise from imperfect embryonic development. The lateral fistulæ arise from imperfect closure of the second gill slit or branchial cleft, as is the case with certain cysts in this locality, while median fistulæ are generally considered to have no connection with the branchial cleft, but to arise, as do the cysts, from abnormality in the development of the thyreoglossal duct. The origin of these fistulæ is of aid in diagnosis because of their characteristic location. As a rule the lateral fistulæ are originally incomplete internally and perforation occurs secondarily later in life.

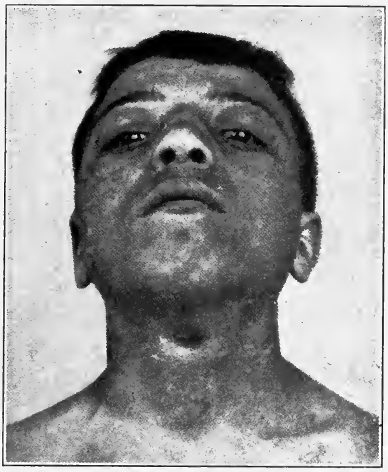


Fig. 481.—Congenital median fistula of the neck. (de Quervain.)

While arising from imperfect embryologic development the *median fistulæ* are usually not congenital while the lateral fistulæ are very commonly so. With the latter there is as a rule a small punctiform opening with a moist surface between the hyoid bone and the thyroid cartilage. It is frequently difficult to pass a probe very far along the fistulous tract because it usually passes directly over the hyoid bone and in some cases passes through it, and there also may be narrowed places which will not admit a probe. The injection of methylene blue solution, or better hot permanganate potassium saturated solution, into the tract is an aid in following it at the time of operation, or its course might be located more accurately by the use of bismuth paste and x-ray. This method is especially valuable, because these fistulæ are frequently very irregular in their structure, and often have a number of branches. This irregularity is frequently increased as a result of unsuccessful operations. After determining the form and extent of the fistula by this method, it is frequently wise to fill the cavity with hard paraffin at a melting-point of 120°, which has been liquefied by heating, and which should be forced into the fistula so that it will fill all the portions of the cavity. It will immediately harden in this cavity and will indicate the form and extent of the cavity so that the entire lining of the fistula can be excised intact. In case the fistulæ have become infected the differential diagnosis between a congenital fistulæ and a sinus leading to a broken-down gland might offer some difficulty. If the lining membrane were excised, however, the true character of the condition would be recognized microscopically by finding characteristic ciliated epithelium lining the fistulous tract.

With the *lateral fistulæ* of the neck the opening is located frequently along the side of the neck between the median line and the anterior border of the sternomastoid muscle. It is said to occur most frequently just above the sternoclavicular articulation, but in many cases the opening is located higher in the neck at the level of the cricoid cartilage or even as high as the thyroid cartilage. The course of the fistula from without inward is through the subcutaneous tissues, the platysma muscle, the superficial fascia, then parallel to the sternomastoid muscle upon the fascia overlying the sternohyoid muscle upward toward the hyoid bone. It usually passes over the origin of the internal carotid, between the internal and external carotid arteries, underneath the digastric muscle, and ends in the lateral wall of the pharynx. In many instances it is closely adherent to the sheath of the great vessels and it crosses the stylopharyngeus muscle as it enters the pharynx. The hypoglossal nerve and the glossopharyngeal nerve usually lie under it. Either the outer or inner portion of this tract may persist, forming an incomplete internal or incomplete external fistula, or the entire tract may remain patulous. The right side of the neck is said to be more commonly affected, and contrary to the case of median fistula it is usually present at birth. The secretion is usually thin mucus which may become turbid, containing pus if the fistulous tract is infected. The quantity varies from a few drops to a sufficient amount to be very troublesome, causing eczema of the skin surrounding the opening. With the incomplete internal fistula particles of food may be retained and give the impression of a diverticulum of the esophagus. The differential diagnosis from fistula leading to broken down suppurating lymphatic glands or other deep infection of the neck is usually easy. Removal of a portion of the fistulous tract and microscopic examination give a positive diagnosis as the fistulous tract is lined with cylindrical epithelium in that portion deeply seated, while the superficial part of the tract is lined with pavement epithelium.

Treatment.—The only certain method of cure is careful excision of the entire tract. With the median fistulæ it is usually possible to accomplish this under local anesthesia. As the fistulous tract sometimes extends over the hyoid bone or even passes through it, complete removal is sometimes difficult, and in some cases portions of the hyoid bone have been resected. It might be possible in certain instances to obliterate a portion of the fistula by injection of some irritating fluid. The injection of zinc chloride solution and pure carbolic acid or strong solutions of silver nitrate have been tried in certain cases, but are not usually successful. The tract is often so tortuous and so narrow in places that probably the caustic solution does not reach every portion of it. If the entire fistulous tract were open there would be considerable danger of such irritating poisonous fluids entering the pharynx. Scraping out the fistulous tracts with a sharp curette is not a successful means of cure. With the lateral fistulæ excision is very much more difficult because of deep location along important anatomical structures. The injection of bismuth paste or of methylene blue solution, or hot saturated solution of permanganate of potassium, might facilitate the removal of these deeper fistulæ, and a liberal skin incision and general anesthesia would be necessary for successful removal of the deep fistulæ. Ponacker simplified the removal of complete fistula by excising the external portion as far as the digastric muscle. He then passed a loop of silk from the internal opening using a probe as a guide and by this means was able to invert the inner portion of the tract and excise it.

INJURIES OF THE NECK.

Burns.—Extensive burns are of special importance in this locality, not only because of immediate danger to life of inhaling flames but because of the tendency to scar tissue contraction, which may draw the head into malposition, resembling true wry-neck or which may otherwise greatly hamper and disfigure the patient.

Treatment.—The superficial burns of the neck may be treated in many different ways with satisfactory results. A thick covering of sterile vaseline which protects from the air, relieves burning and pain and the use of antiseptics is unnecessary if the deeper true skin is uninjured. Deeper burns should be treated like wounds of any other part of the body with as thorough antiseptic precautions as would be used with any wound. The dense scar tissue which causes serious contractures is usually the result of prolonged suppuration and this can be avoided in most cases by a thorough preliminary cleaning up under general anesthesia and careful after-attention. As soon as granulations have formed, skin grafting may be used in the case of more extensive burns. Part-thickness grafts are satisfactory if these cases are taken early, but in the extensive contractures which follow burns pedicle flaps or full-thickness grafts are usually necessary. Frequently several flaps can be turned from the upper part of the chest to cover such a surface on the neck, or a pedicle flap may sometimes be taken from the forearm. In case muscles have been badly matted together in scar tissue it may be necessary to dissect them out and practice some of the methods of muscle lengthening. Transplantation of fat may be used to prevent readhesion.

Injuries of the Deeper Parts of the Neck.—Injuries of the *great bloodvessels* and nerves of the neck are of relatively infrequent occurrence, in times of peace aside from accidental or intentional injury during extensive operations. The experiences of the great war have given a new significance to such injuries. Injury of the large arteries results fatally within a very few minutes, at the most, unless intelligent first aid is at hand. Instruction in first aid, which is now much more generally given than formerly, will doubtless make it possible to save the lives of many. If the hemorrhage is from one of the great vessels of the upper part of the neck it may be possible to arrest it by pressure over the common carotid against the transverse processes of the vertebræ. If the subclavian is injured pressure of the artery against the first rib may be possible. Pressure with the finger immediately over the bleeding point is perhaps more generally useful than anything else while efforts are being made to secure the vessel permanently. A double ligature of the artery involved or arterial suture are of course the only reliable means of permanent arrest of hemorrhage. The ligation of the various arteries will be taken up in detail elsewhere.

Injuries of the *larger veins* may give serious bleeding and this is particularly true of the neck for the reason that the veins do not have valves. In many cases it is possible to control venous hemorrhage by a firmly placed tampon while preparation is made to secure the vessel or bleeding point permanently. The entrance of air into the larger veins of the neck causing air embolus is also a possible source of trouble in injuries of the veins. Recent studies show that air may be injected into the larger veins without producing serious results and it is quite possible that the dangers of air embolus have been considerably exaggerated. It seems that fatal results occur only when the vein is widely open during inspiration so that a large amount of air is inspired quite suddenly, sufficient in quantity to cause an acute dilatation of the heart or the formation of foam or the production of a thrombus. Filling the wound with saline solution or packing in gauze firmly would prevent the aspiration of air into the larger veins in case of injury during operation. Leaving clamps in the wound on the larger veins for considerable time is a method which is occasionally employed, but which we have not used.

Injuries of the *large nerve trunks* of the neck are also of infrequent occurrence except in war. The monograph of Mitchell, Morehouse and Keen on nerve injuries occurring during the Civil War is still one of our most valuable sources of information in these cases and numerous monographs have appeared during the World War, that of Tinel specially careful and complete. A complete report of the results of surgery in the World War will not be available soon, not alone because two or three years must elapse before one can be positive of results in nerve surgery but also because of the vast material to be studied.

Brachial Plexus Injuries.—The brachial plexus is sometimes injured not only by gunshot or stab wounds but frequently by some force separating the head from the shoulder. The plexus, formed of the fifth, sixth, seventh and eighth cervical nerve roots and the first dorsal is of triangular form with the base at the vertebral roots and all trunks converging to the apex at the axilla. Hence lesions at the axillary apex and just above the clavicle usually involve several trunks and the great vessels. That neither fatal outcome or extensive injury may result was seen by three gunshot injuries through this dangerous area

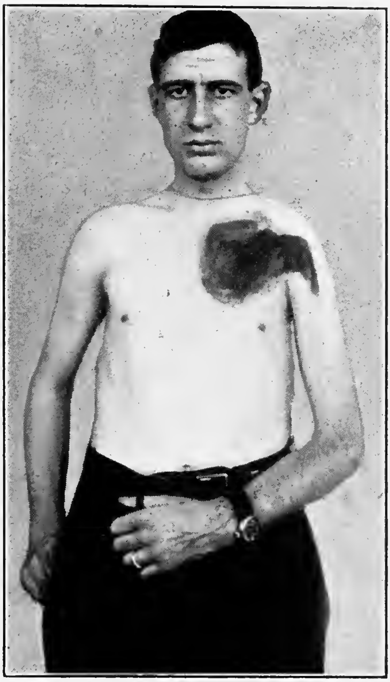


Fig. 482.—Gunshot wound just above the clavicle at the base of the neck, in the neighborhood of the important nerve trunks of the brachial plexus and the great vessels. Dark area shows anesthesia. Flattening of shoulder from deltoid paralysis. This case is one of three gunshot injuries at the root of the neck, observed at U. S. General Hospital No. 26, Ft. Des Moines, Ia., in which patient survived with surprisingly little disability after injury in this important area.

treated at Ft. Des Moines. (See Fig. 482.) The higher spinal nerve roots take an oblique course, the lower ones are almost horizontal. This arrangement of the plexus, (diagrammatically illustrated by Taylor, see Figs. 483–484) puts the strain of forcible separation of the head from the shoulder, first upon the upper cervical roots then upon the next lower roots, in their order from above downward. Gunshot and stab wounds occasionally injure the roots near the intervertebral foramina before they unite to form the primary nerve trunks of the plexus. A case of this kind was observed among the war injuries at

U. S. General Hospital No. 26, in which only the rhomboid muscles were involved. The primary trunks are also occasionally affected. The symptoms resulting are dependent, of course, upon the trunk involved. The fifth and sixth cervical root form the upper trunk; the eighth cervical and first dorsal, the lower trunk; and the seventh cervical the middle trunk. Each of these divides into an anterior and posterior branch. The anterior branches of the upper and middle trunk form the upper secondary trunk of the plexus, which gives off the musculocutaneous nerve and the external root of the median. The anterior branch of the lower trunk constitutes the inner cord of the

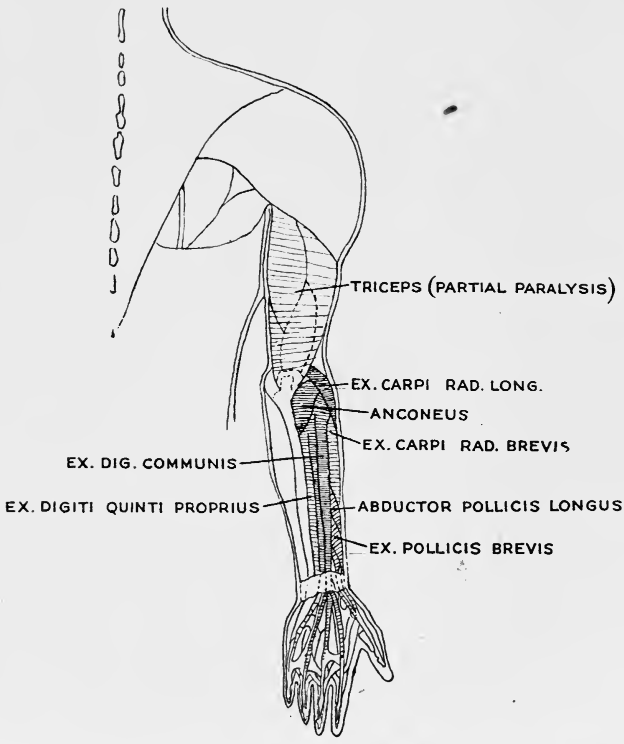


Fig. 483.—Posterior view. Lower radicular group; eighth cervical root and first dorsal.

plexus, gives off the ulnar and the internal root of the median as well as the internal cutaneous and lesser internal cutaneous nerves. The three posterior branches form the posterior cord which gives off the circumflex and afterward forms the musculospiral nerve. The supraclavicular area is essentially that of the primary nerve trunks of the plexus and their branches of division. The diagnosis of certain injuries is fairly easy because of the definite distribution of the nerves. Paralysis of the rhomboid muscles indicates injury of the fifth cervical nerve root as the nerve to these muscles comes directly from it. The nerve to the serratus magnus originates from the fifth and sixth cervical roots. The suprascapular nerve comes from the upper primary cord of the plexus and is almost invariably affected in injuries causing forcible separation of the head from the shoulder. The upper branch to the subscapular muscle also comes from the upper cord of the plexus just after it divides into the anterior and posterior branches which form the secondary cords of the plexus. All the cervical roots send communicating branches to the cervical sympathetic but the branch from the first dorsal is especially important as it carries to the lower

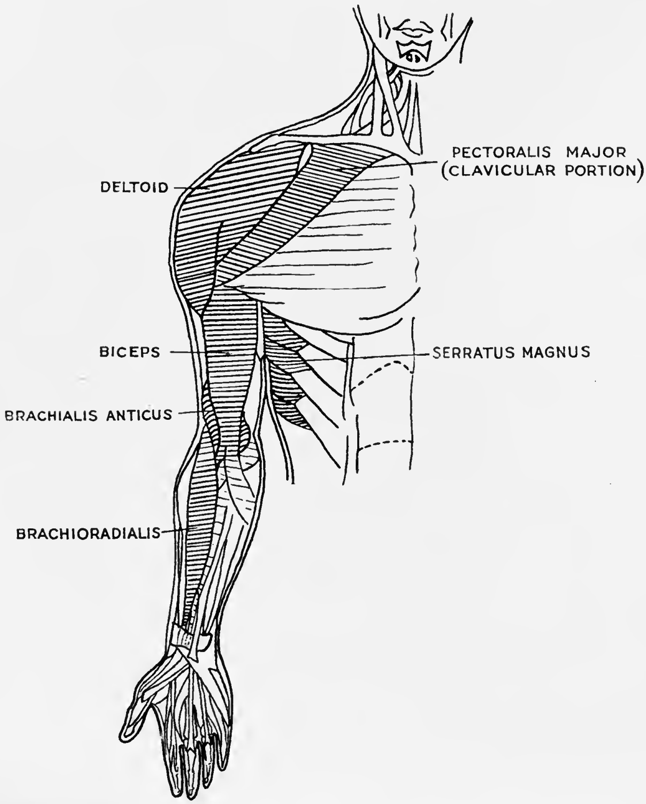


Fig. 484.—Anterior view. Upper radicular group, fifth and sixth cervicals.

cervical ganglion of the sympathetic the ciliospinal fibers which innervate the pupil of the eye.

In injuries of the nerve roots and primary cords of the plexus we have the so-called radicular syndromes. A great number of muscles are supplied by two and often three different roots, consequently partial paralysis of these muscles results and there is tendency to spontaneous improvement. There are also extensive sensory substitutions between nerve roots so that the sensory symptoms are less definite than the anesthesia from lesions of the peripheral nerves.

Three partial radicular syndromes are usually described: First, of the fifth and sixth cervical roots, the upper radicular group forming the upper primary cord of the plexus. This is commonly spoken of as the Erb-Duchenne syndrome. The muscles affected are the deltoid (circumflex nerve); biceps and brachialis anticus (musculocutaneous nerve); supinator longus (musculospiral nerve). There is, of course, complete loss of flexion of the elbow since biceps, brachialis anticus and supinator longus are all gone. There is also paralysis of the clavicular head of the pectoralis major, the supra- and infraspinatus and the subscapularis; and the teres major whose nerve supply comes

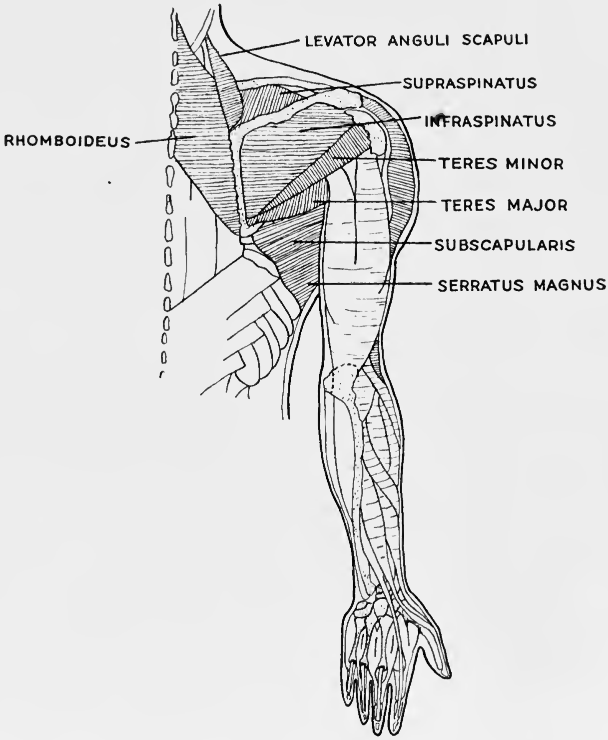


Fig. 485.—Posterior view; upper radicular group, fifth and sixth cervicals.

from the upper primary cord or its branches. If the lesion is near the spinal roots there may be paralysis of the rhomboids, the serratus magnus and the levator anguli scapulæ. The upper radicular groups also partially supplies the coracobrachialis, triceps, the radial extensors and supinator brevis, pronator radii teres and the flexor carpi radialis together with the extensor and flexor muscles of the thumb. These muscles are usually slightly weakened, at least temporarily. There is hypesthesia instead of anesthesia as with peripheral nerve lesions and is indicated in Fig. 486, a photograph of actual injury studied at U. S. General Hospital No. 26.

The middle radicular syndrome is characterized by paralysis of the muscles supplied by the musculospiral nerve, excepting the supinator longus. This root takes its origin from the seventh cervical and forms the middle primary cord of the plexus. The triceps is weakened but not paralyzed, being partially supplied by the sixth cervical. The clinical picture is almost exactly like that of lead palsy. There is slight hypesthesia over the dorsal surface of the forearm and outer part of the dorsum of the hand, as the sensory supply of the seventh cervical is very limited.

The lower radicular syndrome (Aran-Duchenne) caused by injury of the eighth cervical and first dorsal roots which form the primary lower cord of the plexus, is characterized by paralysis of the flexors of fingers, the flexor carpi ulnaris, the interossei, the thenar and hypoth-

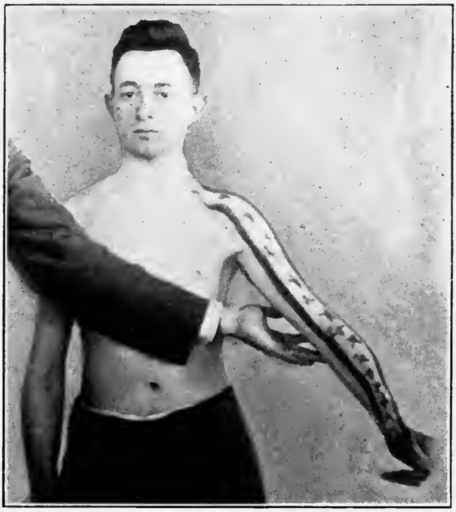


Fig. 486.—Area of hypesthesia characteristic of injury of fifth and sixth cervical roots or upper primary cord of brachial plexus. Gunshot wound treated at U. S. General Hospital No. 26, Ft. Des Moines, Ia.

enar eminences. Those muscles which are supplied by the median are innervated from the eighth cervical while the ulnar takes its origin mainly from the first dorsal. Hence injury gives nearly the appearance of combined paralysis of the median and ulnar nerves, with the flattened hand, if complete division, and griffe, if only nerve irritation. The pronator radii teres and flexor carpi radialis receive from the outer root of the median, fibers from the sixth and even the seventh cervical and are not usually affected in lower root lesions. The sensory area is a band of hypesthesia along the inner side of the arm. Sometimes with injury of the lower roots the oculopupillary syndrome of Mme. Dejerine-Klumpke is present, consisting of myosis, enophthalmos and narrowing of the palpebral fissure.

The syndrome caused by injury of the secondary cords of the plexus resemble peripheral injuries. The upper secondary cord corresponds to paralysis of the musculocutaneous and outer head of the median. The posterior secondary trunk corresponds to musculospiral and circumflex paralysis; the lower secondary trunk, to paralysis of the inner head of the median and ulnar with lesion of the internal cutaneous and lesser internal cutaneous.

Fig. 487.—Circumflex nerve paralysis from gunshot wound. Area of anesthesia in paralysis of fifth cervical root. Degree of abduction of the arm from tilting the scapula. Scar on back from gas burn.

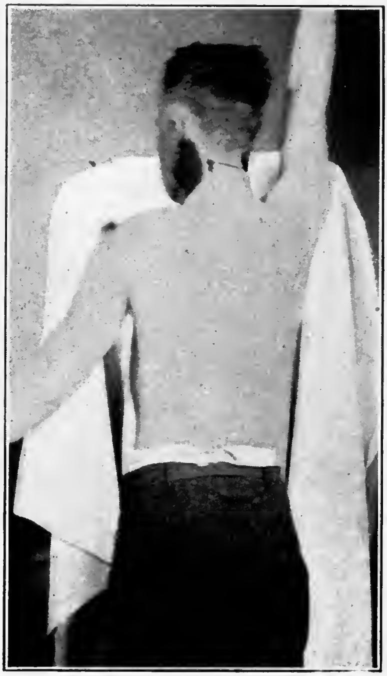


Fig. 488.—Abduction of the arm by action of deltoid. Movement of scapula limited by paralysis of spinal accessory nerve. Note difference between attitude and fulness of the shoulder in this injury and that in which the circumflex nerve is involved.

The nerve trunk injured can be reasonably accurately located by the paralysis or sensory disturbances which follow. Injuries of the cervical sympathetic when irritation only is present may produce paleness and coolness of the skin, protusion of the eyeball, dilatation of the pupil on the affected side. When paralysis results permanent flushing and increased surface temperature of the face results. Disturbance in the heart's action has not been reported. Injury of the pneumogastric causes difficulty in breathing and sometimes sudden arrest of the heart's action. This is far less likely to occur if the nerve is divided than if it is crushed or pulled upon. Paralysis of the recurrent laryngeal nerve with hoarseness may result from injury of the pneumogastric or from pressure on it. Injury of the recurrent nerve itself is unlikely except in operations upon the thyroid or possibly some extensive dissections for the removal of malignant growth. A few injuries of the phrenic nerve have caused paralysis of the diaphragm and lower part of the thorax. While the symptoms have been serious in some cases, no fatalities have been reported and no attempt at treatment has been made. Nerve suture as early as possible has given very

Fig. 489.—Same case as Fig. 488 showing movement of arm possible when the scapula is fixed on the chest wall by the hand of an assistant.

Fig. 490. — Area of hypesthesia characteristic of eighth cervical and first dorsal root involvement, or the lower primary cord of the brachial plexus. Gunshot wound observed at U. S. General Hospital No. 26, Ft. Des Moines, Ia.

satisfactory results when the nerves of the brachial plexus or spinal accessory have been divided. Interference with the vagus is too dangerous to make any attempt at suture seem advisable, indeed when difficult respiration or sudden stoppage of the heart has followed crushing injury, immediate division possibly after cocainization has been advised. The results of injury of the sympathetic have not proved serious enough to warrant any special treatment.

Brachial Birth Palsy.—Brachial birth palsy is an injury of sufficient frequency to deserve special mention. A summary of the essential features of this interesting condition by Alfred Taylor[1] puts the situation as concisely as it can be stated by one who has probably had the greatest experience in the surgical treatment of this condition.

The essential etiologic factor consists in the forcible separation of the head and neck from the shoulder on the side of the lesion. The deep cervical fascia, the nerve sheaths, the nerves and small accompanying vessels are torn. After a time the resulting blood-clot and torn structures form a dense cicatrix which prevents nerve regeneration. As a rule the injury involves the roots in order from above downward, and may vary in extent from a slight injury of the upper root to a complete rupture of the entire plexus. In some cases roots are torn from the cord itself. Secondary pathologic changes occur in the muscles, ligaments, and joint-ends of the bones. The paralyzed muscles are grouped according to the roots injured. The characteristic attitude is marked inward rotation of the whole extremity, which is accented by the pronation of the forearm and hand. There is always some posterior displacement of the upper end of the humerus as compared with the normal side, and in a few cases complete posterior dislocation of the shoulder. Sensory disturbances are slight and usually soon disappear. Interference with growth is always present and is most marked about the shoulder girdle. Deformity usually increases with age. A cicatrix can easily be felt in the region of the damaged nerves, and is usually tender even after years.

Fig. 491.—Before operation. Ordinary attitude of right arm; inward rotation of arm; pronation of forearm; flexion at elbow; marked flexion at wrist. (Taylor.)

Prognosis is bad. There is nearly always some degree of deformity and paralysis which persists.

Operation as early as the general condition will permit (three to twelve weeks) gives the best prospect for a useful arm. In the few cases in which complete spontaneous recovery will occur the paralysis is usually not extensive, improvement starts early, continues rapidly,

[1] Am. Jour. of the Med. Sc., Dec., 1913, No. 6, cxlvi, p. 836.

and operation is contra-indicated. In debatable cases operation amounts to early exploration, with repair of such damage as may be found. There is exceedingly little danger in the operation, which amounts only to an incision through the skin and fat at the base of the neck.

Before operation the extremity should be held in a sling to take its weight off the damaged nerves and paralyzed muscles.

In cases where roots have been torn from the cord they must be laterally implanted into the neighboring roots, or if the neighboring roots have been damaged enough to require resection all of the distal nerve trunks may be sutured in a bunch to the proximal roots still attached to the cord.

After operation the head and shoulder must be held in approximation for weeks by a steel brace fitted before operation.

As Taylor states, the criterion of treatment is its result. In his series of 200 cases reported at the American College of Surgeons, October 1919, 70 were operated upon and in 130 cases, operation was refused by the parents or physician in charge. Of this number there are only 2, or 1 per cent., of spontaneous recovery. Of the 70 operative cases 3 died—1 from status lymphaticus; 1 from gastro-enteritis a week after operation and the third from hemorrhage. There were no perfect anatomical and physiological recoveries but with few exceptions the children made marked improvement and many recovered almost perfect function.

Taylor also reports 14 cases of the Erb-Duchenne type of paralysis in adults. Seven showed evulsion of the roots from the spinal cord, a much higher percentage of severe injuries than in the birth palsy cases. Of the remaining 7, 3 were lost sight of, 1 made a perfect recovery; 1 almost perfect; 1 good and 1 very little improvement, probably because he removed his dressings, stretched his head from his neck and probably pulled apart the sutured nerves. There was no mortality.

Nerve Anastomosis for Facial Paralysis.—This operation has been successful in a considerable number of cases. The diagnosis of the forms of facial paralysis in which it is likely to be helpful is important. Facial palsy from "cold" is considered by Spiller as usually an infective neuritis and operation is usually unnecessary. If the paralysis persists after six months with reaction of degeneration, Spiller recommends anastomosis. The destruction of the nerve in operations for mastoid disease is the most frequent indication for operation and the history of the case is definite enough in such instances. Injury of the nerve from gunshot or other wounds in the substance of the parotid after the nerve has divided into smaller branches, would of course, rule out anastomosis as likely to be a successful form of treatment.

Treatment.—The hypoglossal nerve is probably best adapted for use and it is most conveniently found at the lower border of the digastric muscle as it curves forward between the internal carotid artery and jugular vein and around the origin of the occipital artery. The spinal accessory nerve has also been used and is usually located by the prominent transverse process of the atlas as it passes downward and backward into the substance of the sternomastoid muscle about two inches below the mastoid process. The facial nerve is located by blunt dissection along the upper part of the anterior border of the sternomastoid, carried down between the parotid and anterior border of the mastoid process. The nerve is usually found less than one-half inch from the surface of the mastoid and at the junction of its lower and middle thirds. The prominent styloid process is a guide to its exit from the foramen at its base. It should be isolated and divided as far back as is possible. Another method is to incise horizontally along the posterior border of the parotid very carefully to locate a branch which can be followed back to the main trunk. Electrical stimulation should be used for identification. End-to-end anastomosis is preferable to splitting the nerve and inserting the end as has been suggested by some. Enough free nerve trunk should be isolated to provide for suture without tension. The fact that the hypoglossal brain center is more closely allied to the facial center, makes it a more satisfactory nerve to use and Spiller states that with this anastomosis it is possible that emotional movements may be restored. The associated movement of the shoulder with the spinal accessory anastomosis makes the result peculiar although the ultimate result has, in certain instances, been satisfactory.

Injury of the *trachea* or *larynx* occurs most frequently in attempted suicide by throat-cut. As the head is thrown back, the great vessels are carried deeply into the neck and are seldom injured, but in some cases the trachea is laid widely open. The escape of frothy blood and mucus is more alarming usually to the patient and the bystanders than to the surgeon. If the wound in the trachea is carefully closed and drainage is provided, the results are not usually serious, although infection almost invariably results and recovery is slow.

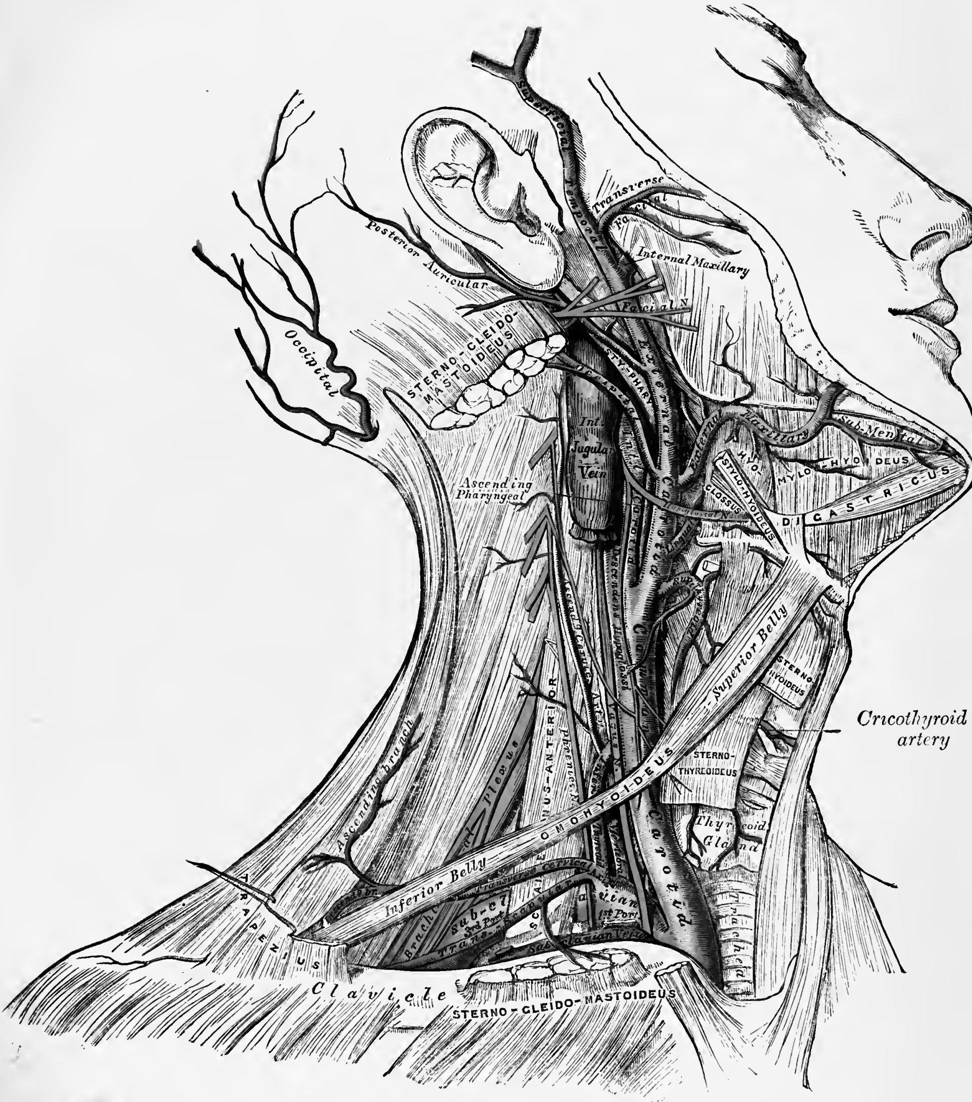
Injury of the thoracic duct is mentioned in connection with the treatment of tuberculous glands of the neck, in which operation it is probably most frequently injured.

DISEASES OF THE NECK.

Aneurysm of the Neck.—As the symptomatology of traumatic or false aneurysm and the spontaneous or true aneurysm of the neck are practically identical it seems unnecessary to discuss them separately.

Diagnosis.—We have to consider first; the distinction between aneurysm and other swellings affecting the neck such as cysts, soft tumors, abscesses and other conditions occupying a similar location, and second; the exact diagnosis as to the bloodvessel which is affected and the location in the course of the bloodvessel. Some distinctive symptoms when present greatly facilitate the diagnosis of aneurysm from other tumors of the neck. These symptoms are due for the most part to the fact that aneurysm is directly connected with the arterial circulation. Pulsation may be transmitted from the great bloodvessels of the neck

PLATE IX



Applied Anatomy of the Arteries of the Neck, Showing the Carotid and Subclavian Arteries. (Gray.)

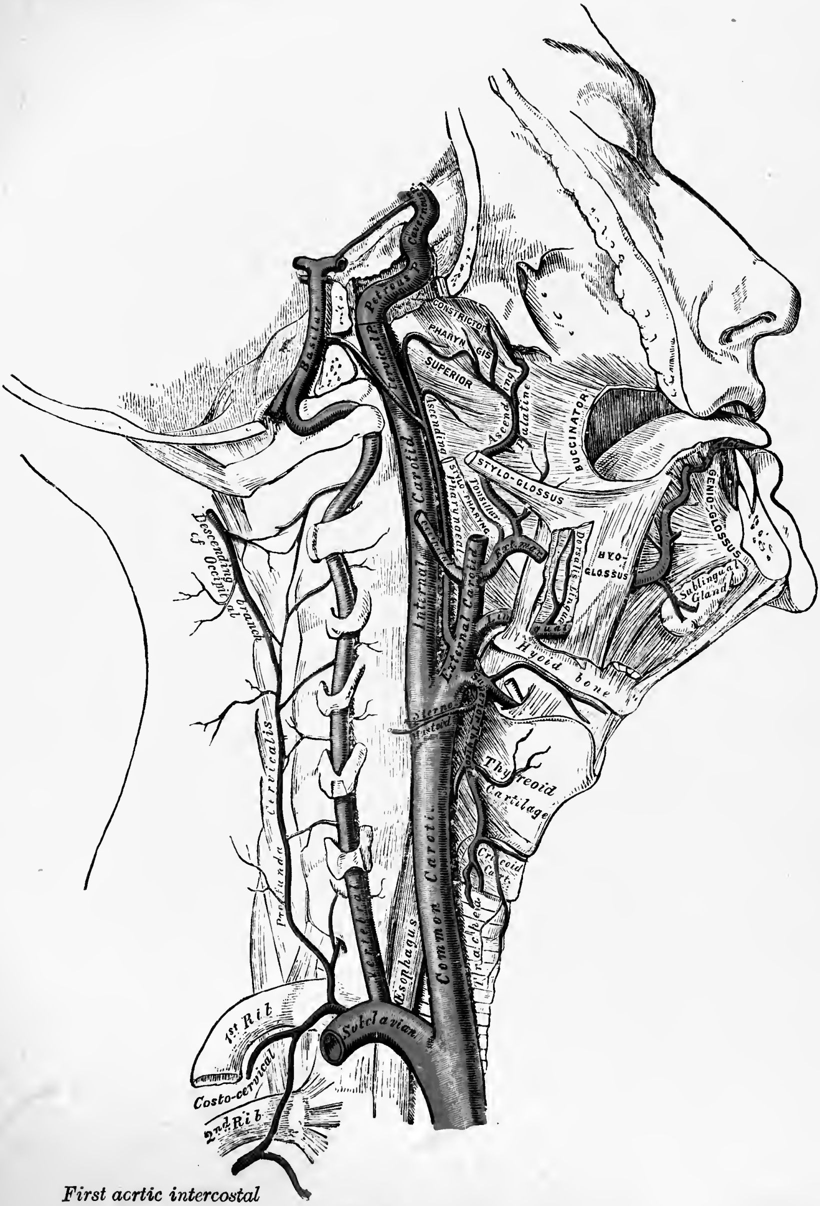
In considering the removal of tumors of the neck, it is of greatest importance for the surgeon to bear in mind the relation of the anatomical structure shown in this illustration, because this will enable him to avoid injuring any of these structures unintentionally.

to overlying tumors but in true aneurysm there is generally expansile pulsation. The tumor is readily compressible and the pulsation ceases upon pressure over the main vessels, between the heart and the aneurysm, in case this is possible. On auscultation the bruit in many cases is distinctive and the aspiration of blood from the tumor is very suggestive. Some or all of these relatively characteristic symptoms may be absent as a result of the fact that clotting may have occurred within the sac thus preventing expansile pulsation, compressibility and bruit. A small amount of blood may also be aspirated from some of the more vascular tumors, as sarcoma or vascular cystic goiter. Among the most characteristic of the circulatory symptoms concerned with the diagnosis of aneurysm is the delay in beat and reduced volume in pulsation of the bloodvessels peripheral to the growth. Pressure symptoms are especially noticeable with aneurysm of the neck because of close proximity to large nerve trunks and other important organs. The symptoms of pressure on various nerve trunks are especially significant. Neuralgic pain and paralysis are frequently seen. Difficulty in breathing and in swallowing are common to certain other tumors of the neck. Brain symptoms due to disturbance of the circulation are more common than with most other growths of the neck. Pressure of the large aneurysmal sac may so reduce the blood supply to the brain as to cause persistent headache, and in other cases, faintness, dizziness, insomnia or hemiplegia may be present. The general symptoms of aneurysm will be discussed more in detail in the chapter devoted to that subject.

The differential diagnosis as to the artery affected and the exact location of the aneurysm may offer great difficulties. Because of characteristic location there would ordinarily be little difficulty in distinguishing between an aneurysm of the external and internal carotid from the subclavian or the innominate. In differential diagnosis of aneurysms affecting the carotids it should be kept in mind that the common carotid is far more frequently affected than either the external or internal carotid, the relative frequency being about 87 per cent. in the common carotid compared with 7 per cent. in the external and about 6 per cent. in the internal carotid. Difficulty in breathing and in swallowing is somewhat frequent with the larger aneurysms affecting the common and internal carotid, much less frequent with aneurysms of the external carotid unless they are of large size. Symptoms from disturbance of circulation of the brain may be present in either aneurysm of the common or internal carotid but would be unusual with the external carotid. On account of their location higher up in the neck, external and internal carotid aneurysms sometimes cause pressure inward on the tonsils, which may be mistaken for a peritonsillar abscess or tumor of the tonsil. Paralysis of the hypoglossal nerve may be present in any of the carotid aneurysms. Paralysis of the recurrent nerve with hoarseness is more frequent in aneurysm of the common and internal carotid. The sympathetic nerves or the cervical plexus may be affected by aneurysms of the common or internal carotid, less frequently by aneurysms of the common carotid. Pressure on the spinal accessory nerve is far more common in aneurysm of the external carotid. Delay and decreased force of the temporal pulse are usual when the common or external carotid is affected, but not usual with involvement of the internal carotid. The differential diagnosis of aneurysm of the innominate artery from that of the common carotid may offer great difficulty, especially if it is located near the origin of the common carotid. The relative frequency is about the same. Pressure symptoms causing difficulty in swallowing and breathing would be present with either, also pressure symptoms affecting the recurrent nerve and brachial plexus. Brain symptoms would be somewhat more frequent with the aneurysm of the common carotid. Delayed pulse and decreased volume would be present in both the radial and temporal arteries in case of aneurysm of the innominate, while only the temporal artery would be affected with aneurysm of the common carotid. This is perhaps the most distinctive of the symptoms in the differential diagnosis between these two forms of aneurysm. The differential diagnosis between aneurysm of the innominate and the first portion of the subclavian would also offer great difficulties in certain cases. Both cause pressure on the brachial plexus, but pressure on the recurrent nerve is more common with innominate aneurysm, while both cause difficulty in swallowing and breathing, the innominate perhaps somewhat more frequently. Delayed pulse-rate and decreased force should be present in the radial artery in case of aneurysm of the subclavian and in both radial and temporal arteries with the innominate aneurysm. Aneurysm of the third portion of the subclavian would offer less difficulty because of its more characteristic location. In addition to the symptoms which are present with aneurysm of the first portion of the subclavian, pressure on the clavicle, which may cause dislocation in some cases, should also be mentioned. Aneurysm of the vertebral artery is extremely rare, only one case having been reported concerning the portion of the artery which lies within the bony canal between the origin of the artery and its exit. Traumatic aneurysms of the extracranial portion of the artery are also very unusual, the symptoms closely resembling those of aneurysm of the internal carotid artery. Pressure on the tonsil would perhaps be considerably less frequent with aneurysm of the vertebral artery and brain symptoms possibly about equally common.

Treatment.—The merits of the various methods of ligation will be discussed in detail in the chapter dealing with the general subject of treatment of aneurysms also aneurysmorraphy, apparently the ideal method recently suggested by Matas; wiring the sac; and the use of the electrolysis, gelatin injection, etc. The technic of ligation will be discussed under the various bloodvessels as such ligations are required in the treatment of injuries of the bloodvessels and various other pathological conditions as well as with aneurysm. The various forms of carotid aneurysms and also aneurysm of the third portion of the subclavian have been treated by compression with success in a number of cases.

PLATE X



The Internal Carotid and Vertebral Arteries. Right Side.
(Gray.)

Digital compression is probably the safest method of treatment, but it is difficult to carry out and by no means free from risk. The possibilities of the clot forming an embolus to be carried to the brain must always be borne in mind. There are also numerous important structures in the neck which are likely to be injured by prolonged compression. A further disadvantage is that the treatment is apt to be very painful, and because of this it has been abandoned in some cases and resort has been made to ligature. Several successes have been reported, however, in this treatment of aneurysm of the common carotid artery, and, while it is successful in obliterating the sac, usually a channel is left through which the blood circulates, which is a further advantage in the use of the method. Successes have also resulted from central ligature applied according to the method of Hunter and also that of Anel. The risk of this method, however, is considerably greater than of treatment by compression. Ligation above and below the sac according to the method of Antyllus gives prompt results but is different and attended by considerably risk. The Matas method would not seem to be any more difficult to carry out, and theoretically more ideal in every respect. He reported at the International Congress of Medicine, in 1913, 7 aneurysmorraphies for subclavian aneurysm, all successful and 4 carotid with 1 accidental death from coronary disease: results not approached by any other method to date. The danger of gangrene of the upper extremity must be considered when any method of ligation is to be used. Whenever blood-pressure in the extremity falls below 35 mm. of mercury there is considerable danger of gangrene. To test the results of this method Matas had used an aluminum band which has been also tried experimentally by Halsted and others, and, in case there is risk of gangrene, the clamp can be removed after three or four days without danger to the artery. Aneurysms located near the origin of the common carotid artery are treated in the same way as aneurysms of the innominate. Aneurysms of the external and internal carotid have been treated most frequently by ligation of the common carotid, especially if they are located near the bifurcation of the common carotid. This is a safer procedure probably than the attempt to ligate the vessel involved nearer to the sac. In treatment of aneurysm of the innominate artery peripheral ligation according to the method of Brasdor or Wardrop have been most commonly used. In recent years wiring and electrolysis have been used in a number of cases and with success by Stewart and Salinger, Finney and others. In case peripheral ligation is used it would probably be safer to ligate the carotid first, so that embolism of the brain would be less likely. Aneurysm of the subclavian artery has been treated by compression, by ligation, also by double ligation and excision according to the method of Antyllus. In case it is located near its origin from the innominate, peripheral ligation has been resorted to in many cases. It would seem that the method of Matas in many cases would be better suited than any of the methods of ligation which have been previously used. In case of aneurysm of the vertebral artery ligation according to the method of Hunter can usually be carried out, and because of the artery's location it would be the best method in the majority of cases.

The statistics as to the results of treatment of aneurysm are made up for the most part from cases operated upon in the early antiseptic days, in some cases from work done in pre-antiseptic days and for this reason they probably seem more discouraging than they actually are at present. The non-operative methods of treatment, prolonged rest in bed, the use of potassium iodide and dieting, and the intravenous use of gelatin to induce clotting frequently give relief but probably seldom, if ever, result in cure. These methods of Valsalva, Tufnell and Balfour are much less in favor since the introduction of antiseptic surgery.

Actinomycosis.—Diagnosis.—Actinomycosis of the neck has to be distinguished from subacute or chronic infections caused by ordinary pyogenic organisms; from tuberculous infections; from carcinoma or sarcoma; and from tertiary syphilis. It could usually be distinguished from pyogenic infections by its extremely chronic course, although in certain cases the infection is a mixed one and in such cases there might be considerable difficulty. The location of the infection in the upper part of the neck, more frequently than any other part of the body except the mouth and jaw in the beginning, might be of some help. The disease frequently finds entrance through carious teeth and spreads from the mouth and jaw to the upper part of the neck in the region of the angle of the jaw, along the lower border of the jaw or under the chin. Actinomycosis is ordinarily a superficial infection, not involving the glands of the neck as do the acute infections, tuberculosis, malignancy and syphilis. Aside from its origin, superficial location and chronic course, the boardlike hardness, alternating with soft areas when the growth breaks down, is somewhat characteristic. The skin in the region of the soft areas is usually a livid purple color. The growth is not as sharply delimited and it tends to break down and heal with the formation of a good deal of scar tissue. Absolutely diagnostic is the discovery by microscopic examination of the characteristic ray fungus. The lack of any definite limitation of the growth, the tendency to soften and break down and discharge material containing ray fungus, and the lack of original glandular involvement would usually give no difficulty in distinguishing the growth from sarcoma or carcinoma of the neck. From tuberculosis it differs in the usual superficial location of the growth, while tuberculosis frequently involves the deeply seated glands along the great bloodvessels of the neck. It also differs from tuberculosis in hardness, lack of limitation and the tendency of certain areas to soften and break down. Reaction to the tuberculin test and especially finding the ray fungus would distinguish it in any case. In case the primary infection is located in the tonsil, the swelling may be deep-seated, and in these cases in the absence of an external opening, actinomycosis is almost certain to be mistaken for tuberculosis, especially if the primary lesion in the tonsils may be so small as to be overlooked.

In these cases, however, the characteristic appearance of the infected tissues at the time of operation is likely to result in a correct diagnosis. If tertiary syphilis is suspected the Wassermann reaction should be used before specific treatment is given, as actinomycosis reacts favorably to antisyphilis treatment, also, and this might give considerable difficulty in distinguishing it from tertiary syphilis.

Treatment.—The treatment is usually successful if undertaken early and persisted in. Incision and curetting out with the sharp curette, the part of the growth which has softened, swabbing with pure carbolic and packing with mildly antiseptic gauze is ordinarily all that is needed. The use of the actual cautery or of very caustic chemicals is probably undesirable and unnecessary in the majority of cases. The iodide of potassium and other iodides have been extensively used both by mouth and by injection directly into the growth. There is a widespread belief that the use of the iodides has a favorable influence on actinomycosis and practically all patients receive these remedies usually internally, but occasionally injected. When injected into the growth a 1 per cent. solution of the iodide of potassium is ordinarily used, injected either daily or at somewhat longer intervals. In other cases 2 or 3 drams of Lugol's solution has been used in place of iodide of potassium. The use of some of the iodides, especially the iodide of potassium, in connection with surgical treatment would be desirable on the basis of experience of many observers. Small doses are valueless, 60 to 90 gr. followed by a pint of hot water at eight-hour intervals, t. i. d. for three days; then a week of rest, continued for six weeks; then three days' treatment each month for six months, have given permanent cure without operation in some cases. Early and persistent treatment is desirable in order that spread of the growth may be prevented. While the tendency is toward superficial involvement, occasional cases have occurred in which the growth has spread along the fascia and deep bloodvessels of the neck involving the mediastinum or occasionally the pleura and lungs. Spread of the disease upward along the spinal column toward the base of the skull and the brain with fatal outcome has also been observed in neglected cases. If the disease goes on for a considerable time the prolonged suppuration also has a tendency to cause amyloid degeneration of the parenchymatous organs, and dangerous cachexia. Swabbing the wound after incision and curettement with some mildly caustic antiseptic solution also tends to sear the tissues and prevent reinfection of the wound and further spread of the disease. It is perhaps unusual to get a cure by one or two energetic treatments, but if treatment is persisted in and is made as thorough as possible there have been an encouraging number of cures reported.

Syphilis.—All the tissues of the neck are liable to involvement in tertiary syphilis. Ulceration of the skin, involvement of the lymphatic glands, periostitis of the hyoid, and chondritis of the laryngeal cartilages have been reported. Primary and secondary syphilis causes involvement of the lymphatic glands of the neck as a rule. Modern laboratory studies have contributed greatly to the accuracy of diagnosis in difficult cases. A four plus positive Wassermann reaction or demonstration microscopically of the Spirocheta pallida in the secretions from chancre, moist papules or mucous patches, give definite diagnosis, if obtained. The clinical history may be so clear as to make laboratory diagnosis almost unnecessary in some cases. In doubtful cases careful inquiry should be made into the history, no matter what the social standing or position in life of the patient, and frequently there will be brought out a history of some or all of the characteristic lesions: an indolent sore, skin eruptions, falling of the hair, sore-throat, cachexia and general glandular involvement. In extragenital syphilis the lymphatic glands of the neck are involved more frequently than any other group in the body. The submental, submaxillary glands and those above the angle of the jaw are most frequently affected with primary lesion of the lip, the tongue or the tonsils. The symptoms of glandular involvement in the neck are considerably more acute as a rule than the involvement of the glands of the groin. Sometimes there is a good deal of pain, considerable adenitis and the tumor may reach the size of a goose egg. It may be somewhat fixed by infiltration of the surrounding tissues. The appearance of such glandular enlargement rather suddenly in a person formerly in good health, especially if a primary lesion can be located in the region of the mouth, is quite suggestive, and usually with the help of modern laboratory methods there would be little difficulty in diagnosis of acute involvement of the glands from ordinary infectious causes. In secondary syphilis there would be a general glandular enlargement as well as of the glands of the neck; enlargement is rarely so great as with primary syphilis, usually not larger than a pea; and the glands are hard, freely movable and painless. The clinical history and symptoms usually leave little doubt as to the character of the glandular enlargement and the diagnosis could be confirmed by laboratory methods. In tertiary syphilis ulceration of the skin is not so very uncommon; the ulcer is usually painless and extremely indolent in its course; the contour is irregular and ragged, and the edges are undermined and the base covered by secretion. Usually there is little difficulty in diagnosis from ulcers of other causes if the history is carefully taken. The history of an injury or burn; the small scab coming off and leaving a bleeding surface which gradually enlarged in the case of epithelioma and the characteristic appearance of lupus are usually sufficiently diagnostic. Of the deeper soft parts, the muscles of the neck are sometimes affected in tertiary syphilis, the sternomastoid very much more frequently than any other muscle. The myositis may be of a diffuse sclerosing form or more frequently a gummatous tumor appears. The lower part of the muscle is most frequently affected and the involvement may be symmetrical. There is rarely any disturbance of function and little, if any, pain. There are rather rare cases of gummatous glandular involvement in the tertiary stage. These tumors grow very slowly; are not painful, either spontaneously or upon pressure; the consistency is firm and elastic and there are no adhesions to surrounding tissues except that in the later stages the skin is sometimes involved and breaks through forming characteristic ulcers. As the other manifestations of syphilis are usually past at this stage, the diagnosis may be somewhat more difficult, but the Wassermann reaction would be of great help in such cases. There have been extremely rare cases of syphilis affecting the hyoid bone and also the cartilages of the larynx. Either single or multiple periosteal nodes may appear. These are either isolated or appear in connection with chondritis of the thyroid cartilage. In certain cases there is considerable pain with swallowing, difficulty in speaking and some difficulty in the movements of the head and neck.

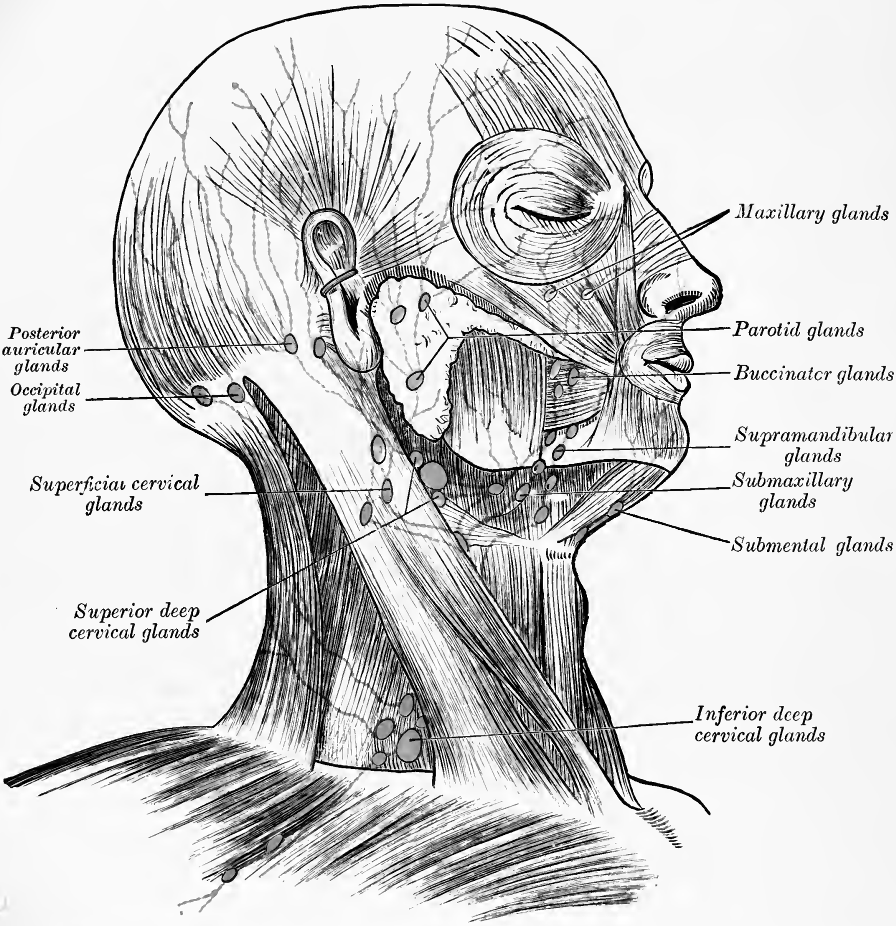
Treatment.—The use of salvarsan intravenously or of neosalvarsan has given great improvement in results in treatment of all forms of syphilis. There has been some disappointment in the fact that one treatment is not always sufficient, but if the treatments be repeated until several negative Wassermanns are obtained the patient may be considered cured. Many advise using active mercurial and iodide treatment in connection with the salvarsan. Active operative measures would of course be contra-indicated in case the positive diagnosis of syphilis were possible. Ulcers or broken down gummas should be treated by ordinary antiseptic measures and usually heal promptly under suitable antisyphilitic treatment. Attention to the general health of the patient should not be neglected in connection with the specific treatment of syphilis—hygienic measures and general tonics are sometimes of great value.

Chronic Inflammatory Processes Affecting the Neck.—Chronic inflammatory conditions in the neck are most commonly of specific origin, chiefly tuberculosis, also actinomycosis and syphilis. While these specific infections form the great bulk of such conditions, certain chronic inflammations are caused by one or more of many pyogenic organisms. The so-called *ligneous abscess* "phlegmone ligneuse" of Reclus is probably of such origin, the infection being too attenuated to produce much pus but keeping up a prolonged inflammation resulting in dense, board-like hardness. There is little tenderness, pain, fever or tendency to suppuration; it may remain stationary for long periods; incision may show purulent exudate in the intermuscular spaces. Simple hyperplastic enlargement of the glands of the neck, chronic lymphadenitis, is not infrequently seen as the result of some irritation in the skin of the scalp or neck, mucous membranes of the mouth or throat, or tonsils and adenoids, and the accessory sinuses. The differential diagnosis has to be made from the cysts and solid tumors of the neck; from tuberculosis, actinomycosis and syphilis; and from the metastatic glandular involvement in the malignant tumors, especially those which are located with difficulty in the pharynx or esophagus. A positive diagnosis is frequently impossible even if the glands are removed and examined microscopically. The Wassermann four plus reaction, the tuberculin test, and the appearance of the ray fungus in the pus from actinomycosis, would be sufficient to give a positive diagnosis, if present. The age of the patient would be of some help in case malignancy were under consideration, malignant growths usually affecting patients in adult life or older, while the chronic hyperplastic inflammations are far more frequently seen among children, especially among young children. The enlargements are frequently small and multiple, while with cysts or solid tumors of the neck the growth is usually single and larger. The characteristic location might be of some help in differential diagnosis from certain cysts. Aberrant thyroids are usually larger, though the location may be similar. Dermoid tumors of the neck are always single and located in the submaxillary region. The presence of some source of chronic irritation, especially eczema of the skin of the scalp or neck, pyorrhea alveolaris, tonsillitis, enlarged adenoids, or chronic disease of the sinuses might be evident causes of possible glandular enlargement. Such enlargement from some cause of chronic irritation would usually disappear unless necrosis or pus formation had occurred when the cause was removed. In case of doubtful diagnosis the cause of the supposed irritation should be removed and the case kept under observation. If there is doubt as to tuberculosis, malignancy or Hodgkin's disease, a gland might be removed for examination.

Fig. 492.—Woody or ligneous phlegmon of neck. Struck by steel two months ago. Slow, painless onset of induration, which extends from mandible nearly to clavicle, and from larynx to anterior border of trapezius. Skin red, slight edema, and pitting on pressure. No tenderness. Poulticed for three days, then incised. Rapid recovery. Episcopal Hospital. (Ashhurst.)

Treatment.—Usually the removal of the cause is sufficient to give relief. If the enlargement persists, especially if there is doubt as to the diagnosis, excision of an enlarged gland would be advisable. Attention to the general health, good nourishing food, fresh air, bathing and use of suitable tonics would be of a good deal of value in many of these cases as well as in the treatment of tuberculosis. Painting the skin overlying the glands with tincture of iodin, rubbing in various iodin salves, or the use of mercurial ointment, are favorite measures in the hands of many observers and have the value of harmlessness, unless the skin is blistered or the tissues otherwise injured. If softening and other evidence of pus are present, incision and drainage are of course necessary.

PLATE XI



Superficial Lymph Glands and Lymphatic Vessels of Head and Neck. (Gray.)

Tuberculous Cervical Lymphadenitis.—Before the discovery of tubercle bacilli such involvement of the glands of the neck was spoken of as scrofulous swelling, and in the pre-antiseptic days many forms of treatment were in vogue which gave a fair percentage of cures, probably more because of the resistance of the patients and infection of low virulence than because the methods had any particular virtue. Recent publications, especially those of Demme of the Jenner Children's Hospital in Berne, and those of Dowd and Mitchell have shown that serious disease of other organs of the body especially the lungs is likely to follow neglected tuberculosis of the glands of the neck and that radical removal offers by far the best prospect of relief.

Diagnosis.—The clinical picture of tuberculous glands of the neck is so varied that there are occasional cases in which a positive diagnosis is difficult. We may find anything from moderate-sized freely movable, enlargement of a single gland to extensive involvement of the entire chain on both sides of the neck, sometimes with extensive abscess formation or old discharging fistulæ. Generally an entire group of glands is enlarged, the individual glands varying greatly in size and matted together by the inflammatory periadenitis. There is usually little, if any, tenderness or pain unless there is a mixed infection. The constitutional symptoms are not severe. Fever is not present as a rule and frequently there is little, if any, loss of weight and strength. Patients at all ages of life may be affected, although the condition is more common in children. The general tests for tuberculosis may be of value if it is possible to carry them out. The tuberculin reaction is reliable if properly used, but of course may indicate tuberculosis of some other part of the body. If material is injected into a guinea-pig the characteristic changes usually follow. Tubercle bacilli are not often obtained by smear or culture from the pus of broken-down glands and are very difficult to demonstrate in microscopic sections. Anatomical tubercles are usually readily found in microscopic sections. The gross appearance of caseous or broken-down glands is fairly characteristic.

Other conditions causing glandular enlargement should first be borne in mind in the differential diagnosis. The general glandular enlargement of syphilis, especially if the epitrochlear or other unusual glands are involved, usually gives little difficulty. The history of chancre, characteristic lesions of the skin and its appendages and of the mucous membranes, would make the diagnosis still more certain. In doubtful cases the Wassermann reaction should always be used.

Leukemia or pseudoleukemia could be ruled out, if there were any doubt, by the blood examination. Malignant lymphoma, lymphosarcoma or Hodgkin's disease may give considerable difficulty in early cases. Later in the disease extensive glandular involvement with rather characteristic appearance of the neck and the effect on the general health would be very suggestive. The glands are also much more likely to be freely movable than with tuberculosis, in which the masses are somewhat fixed by periadenitis when the enlargement has reached considerable size. In doubtful cases a gland should be removed for microscopic examination. Metastatic involvement of the glands from carcinoma would ordinarily offer no serious difficulties in diagnosis. The occasional cases of primary carcinoma are much more difficult, but in any doubtful case a thorough excision should be undertaken. In the broken-down glands of actinomycosis the characteristic microscopic appearance of the pus would settle the diagnosis. Enlargement of the thyroid would ordinarily offer no difficulty because of its movement with the larynx on swallowing, its characteristic location, the single enlargement, and the history of the case. The various cysts of the neck are frequently characteristic in their location and relation to other anatomical structures, usually single and do not ordinarily offer much difficulty.

Fig. 493.—Tuberculous glands of both sides of the neck. (de Quervain.)

Treatment.—Various palliative measures of treatment have been in favor during the past few years. The x-ray treatment has apparently given some positive results, but as the x-ray specialists are just beginning to reach positive conclusions about accurate dosage, it is still uncertain just what the value and limitations of this method of treatment should be. Apparently it has given best results in less advanced cases where there is no caseation, certainly no pus formation, in other words the cases which have given very favorable results with general constitutional measures, in many of which there may have been only hyperplasia without actual tuberculosis. About the same may be said of the therapeutic use of tuberculin. Some writers have advised the after-treatment by x-ray as a preventive of further trouble. The value of the method is still in doubt and it certainly should not be too long continued where uncertain results have been obtained.

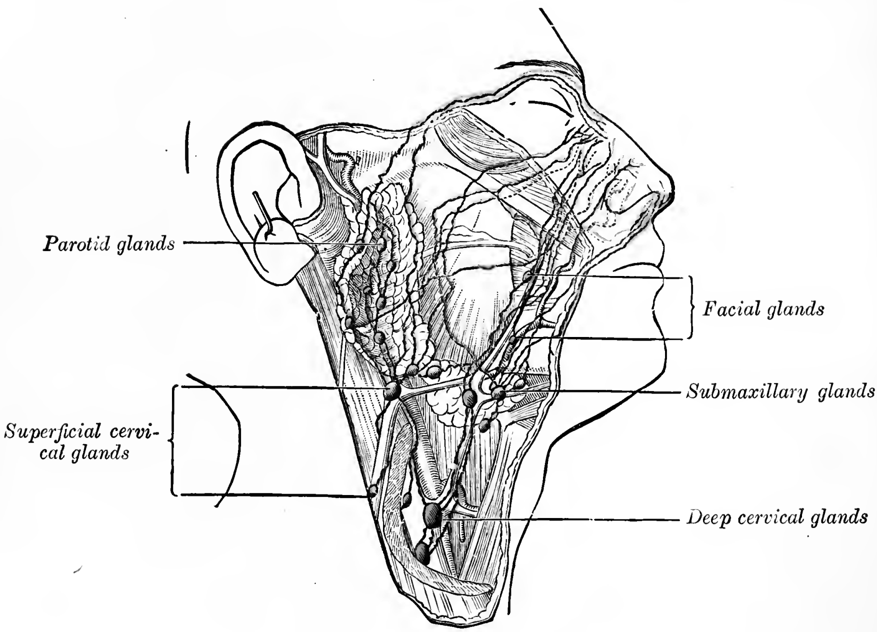
Aspiration of the pus in broken-down glands and injection of various antiseptics has had a number of advocates. Iodoform emulsion, tincture of iodin, carbolic acid, zinc chloride, and the camphorated naphthol solution of Calot have been used. In certain cases the antiseptics have been injected into glands that have not broken down with the idea of producing suppuration. The pus is then aspirated, further antiseptics injected and in certain cases a compression bandage is applied. It is evident that every diseased gland must be treated if satisfactory results are to be obtained, and, considering the extent of the involvement in the majority of these cases, it would seem to have a decidedly limited field of usefulness. Calot admits that skin ulceration and scarring very frequently result.

Operative Treatment.—Considering the risk of involvement of other parts of the body, operative treatment should not be delayed in case reasonably prompt results are not obtained by other measures. We consider it the method of choice in persistent enlargement of much size. The extent of operation varies widely, depending upon the location, duration, and extent of the disease. Frequently a group of enlarged glands can be removed through a small incision under local anesthesia, making the operation a relatively minor affair. The permanent results in such cases are better than when the disease is neglected until extensive involvement has occurred. It is entirely possible to remove all diseased glands without an extensive operation in many cases, and we have a number of cases who have been under observation from five to ten years after such local excision with entire freedom from recurrence. Considering the slight extent of the operation, trifling after-effects, little scarring and excellent permanent results, this would seem to have a claim to be the operation of choice in cases among intelligent people seen early.

Incision, curetting and drainage of a single broken-down gland or a small group of infected glands may give permanent results where there is slight involvement of decidedly limited extent. As with forms of tuberculosis affecting other organs, the results with tuberculosis of the glands of the neck treated in this way are especially favorable with children, when conditions of living can be made satisfactory. With older patients, if any caseous glands are left behind, suppuration will usually continue for weeks or months until the diseased tissue is thrown off, leaving very disfiguring scars and decided risk of tuberculous involvement of other parts of the body.

Complete Excision of the Glands of the Neck.—Under this heading may be included complete excision of any of the larger groups of glands not necessarily including the dissection of both triangles of the neck where the disease is limited to one only. The adjective complete should refer to removal of the disease rather than extent of operation. The normal incisions suggested by Kocher, placed along the line of natural folds of the neck, are used by a large number of surgeons who have had extensive experience with this operation. For the anterior triangle of the neck the incision is placed below the lower border of the jaw about one or two finger-breadths, extending forward from just below the tip of the mastoid process to the middle of the neck or even beyond. In case both the anterior and posterior chain are involved a second incision may be placed parallel to the clavicle over the lower part of the neck, the double incision giving far more satisfactory results as regards scar than a single longitudinal incision. The greatest possible variety of incisions has been recommended. An oblique incision on the posterior surface of the neck, which may be placed just within the border of the hair-line, may be combined with either the upper or lower transverse incision and it adds very little to the disfigurement. Dowd joins the incision within the hair-line with the upper transverse incision and calls it the elbow incision. This gives an entirely satisfactory exposure, particularly when the glands of the upper anterior triangle are most extensively involved. Krüger joins the incision along the hair-line with the lower transverse incision, making it a bow-shaped rather than elbow incision, and this gives also an extremely satisfactory exposure in case of extensive involvement. We have been able to remove extremely adherent masses of glands in the region of the angle of the jaw and at the bifurcation of the common carotid artery by retracting the flap formed by the low transverse incision joined to the incision within the hair-line, with entire satisfaction. If the glands are deep-seated and adherent, it is extremely important to get a good exposure in order to avoid important anatomical structures and satisfactorily to avoid and control hemorrhage. Division of the sternomastoid muscle gives better exposure, but is usually unnecessary. The contour of the neck is better if division can be avoided. In the more extensive cases a flap of skin and underlying platysma muscle is reflected, and in case it seems best to divide the sternomastoid, that too can be included with the flap. In some of the more difficult cases the omohyoid muscle forms a convenient guide to the great bloodvessel sheath. Dissecting along the posterior border of the sternomastoid muscle, the omohyoid can usually be readily located, and by making taut the tendinous portion, it can be readily followed forward where it directly overlies the internal jugular vein. Once having located the vein, injury is not likely to occur. Avoidance of injury to the internal jugular, the spinal accessory nerve, and the lower filament of the facial nerve are emphasized by all writers on this subject. To avoid injury of the vein there should be no forcible blunt dissection immediately in its neighborhood. Firm packing of the lower part of the wound has been suggested to make the vein prominent so that it is readily seen. In case oozing obscures the field it can sometimes be cleared up by the anesthetist's allowing the patient more air or oxygen if a closed anesthetic apparatus is used. Some suggest passing ligatures about the vein so that it may be readily secured in case it is injured. If the vein is injured it is most frequently one of the branches that is torn off, and the vein itself is injured in an attempt to secure the branch. Dowd's suggestion, that it is better to pack that part of the wound and go to some other part of the field of operation for the time, will make the problem of securing the bleeding vessel relatively simple in most cases.

PLATE XII



The Lymphatics of the Face. (Gray.)

If torn, the vein can be secured by lateral ligature by a fine silk stitch over clamps, or in some cases by an entire ligation of the vein. This ordinarily gives no troublesome results and from 5 to 10 per cent. of such ligations are reported by a number of surgeons. That it may not be entirely free from danger is indicated by three fatalities reported by German surgeons and collected by Dowd. The inspiration of air can usually be avoided by a compress firmly placed over the vein or by squeezing a spongeful of saline solution or sterile water into the wound, if one of the larger veins of the neck is injured.

Injury to the spinal accessory nerve should be avoided if possible, for paralysis resulting gives very unsightly deformity; drooping of the shoulder, and usually tilting outward of the angle of the scapula sometimes spoken of as "angel wing" deformity. The nerve frequently passes directly through a matted mass of glands and when stained with blood it is difficult to distinguish from the gland capsule, but there are a sufficient number of reliable anatomical relations that help in locating the nerve so that injury should seldom occur. Three of these are of special value: The nerve passes directly in front of the prominent transverse process of the atlas which can practically always be located; it is covered above by the posterior belly of the digastric muscle which can also be located without trouble; it runs downward and backward into the substance of the sternomastoid muscle and slight pinching of the nerve with forceps will usually cause drawing up of the shoulder. The mass of enlarged glands can be dissected free and drawn down underneath or over the nerve, but sometimes it is more convenient to divide the bunch in order to avoid the nerve. Immediate suture of the nerve generally results satisfactorily in case the injury is recognized.

The lower facial nerve filament (ramus anastomoticus collomandibularis Jaffé) when divided causes disfiguring paralysis of the lower lip which is usually temporary but may persist. An excellent illustration from a dissection made for Dowd gives the location of this filament and his rules for avoiding this branch deserve mention. (1) Transverse incisions three-quarters of an inch below the angle of the jaw seldom injure it, especially if the skin is retracted downward and the platysma and deep cervical fascia are divided at a lower level. (2) Since it crosses the border of the jaw with the facial artery, incisions in front of the artery do not touch it. (3) Since it goes into the neck at about the anterior border of the sternomastoid muscle, incisions posterior to the muscle do not injure it. (This is true of the vertical branch of the elbow incision which is located within the hair-line.) (4) Since it lies on the deep cervical fascia and below the platysma, dissections between these structures should be avoided, and incisions should be made through them below the level of the skin incision and they should be retracted upward with the filament between them. Careful adjustment of the fascia (suture of fascia and platysma) should be made at the end of the operation so as to favor repair if any injury has taken place.

Injury to the thoracic duct has been reported a number of times without any fatalities or serious results which could be attributed to this injury. Six cases were treated by packing the wound; 7 by ligation and 2 by suture. We have one additional case treated by packing to report. For a number of days there was a considerable oozing of milky looking chyle which gradually decreased and subsided without materially lengthening convalescence. Injury of the phrenic, pneumogastric, hypoglossal, glossopharyngeal or sympathetic nerves, or the carotid artery, or its important branches are avoided if the operator keeps close to the gland capsule in his dissection. Division or injury of large branches of the superficial cervical plexus is not easily avoided in many cases, but results only in temporary anesthesia with occasional shooting pains as nerve regeneration occurs.

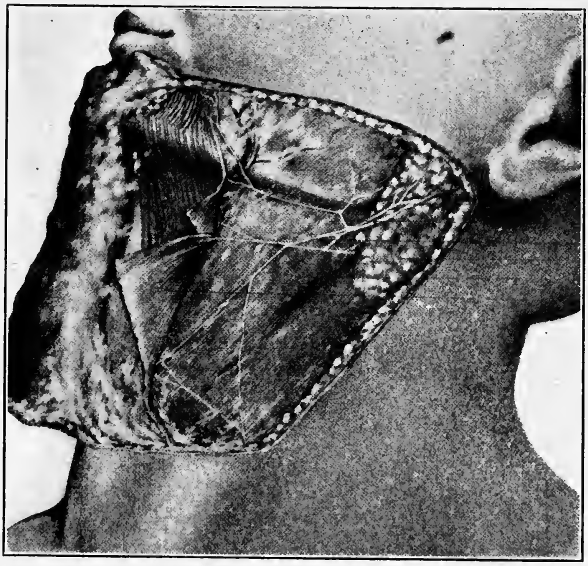


Fig. 494.—Dissection showing lower filaments of the facial nerve, especially the "ramus anastomaticus collomandibularis," Jaffé, which supplies the depressor labii inferioris. *A*, cervicofacial division of the facial nerve; *B*, ramus anastomaticus collomandibularis; *C*, filament to platysma myoides; *D*, parotid gland; *E*, deep cervical fascia; *F*, platysma myoides. (Dowd, Annals of Surgery.)

Some authorities advise against attempting complete excision if there is abscess formation and especially if fistulæ are present. The extensive adhesions in long standing cases, especially if there has been previous incision and drainage or injection treatment, certainly give rise to many added difficulties, but recently an increasing number of these cases are being radically operated upon. It is usually possible to avoid extensive soiling of the wound, if it is packed with gauze to protect clean areas and the pus is mopped up immediately when encountered with the least possible smearing and soiling of instruments and protective dressings. If all broken-down material is carefully removed with a curette while the main wound is so protected and the cavity remaining is stuffed with a sponge soaked in some antiseptic solution, it is possible to proceed with a clean block dissection which will remove practically all diseased glands and the resulting extensive wound usually heals without much, if any, delay. Of course in such cases it is especially important to provide for free drainage. Even in the cases in which it is possible to do a perfectly clean dissection, drainage is desirable, for dividing many lymph channels is unavoidable and there is rather profuse drainage of lymph, serum and some oozing blood. The drainage should be removed within the first few days or permanent sinuses may result. To avoid disfiguring scar, a separate drainage opening should be made near the base of the neck, just above the clavicle or below the sternal notch. A thick moist dressing encourages drainage, especially in the infected cases and should be changed frequently at first. The writer has used Carrel-Dakin treatment with rapid, clean healing in several cases with abscess formation. The main incisions are sutured and thin gauze strips are used just sufficient to separate infected planes. Gauze strips and Carrel-Dakin tubes are both inserted through independent drainage openings. Careful arrest of hemorrhage by securing all bleeding points with ligature is important. A special stitch approximating the platysma and fascia improves the appearance of the scar. Subcutaneous skin closure avoids stitch hole scars which are likely to be disfiguring in infected cases.

The after-treatment of these cases is of great importance. The patients or friends who are responsible for them should understand that those who have had tuberculosis in any form are susceptible to further trouble; that it is impossible to remove every lymphatic gland from the neck and only by persevering attention to general hygienic living can they expect to avoid recurrence of the disease in some part of the body. The use of tuberculin as a curative measure has been lauded by a number of writers but we have seen quite a large percentage of failures even in the hands of the advocates of this treatment. It is possible that it may have some value in the after-treatment of such cases. The importance of out-of-door life, out-of-door sleeping if possible, keeping nutrition up and avoiding overexertion is not less important for a cure in surgical forms of tuberculosis than in tuberculosis of the lungs. Reports from a number of clinics show permanent cures in 70 to 80 per cent. of patients who have had the radical operation, while Demme's report on 692 patients treated at the Children's Hospital in Bern by constitutional measures without surgery shows nearly 30 per cent. of cases in which tuberculosis of the lung, intestine, brain membranes or genito-urinary tract occurred, without mentioning the rather numerous infections of bone and joints. A more general knowledge of the possible grave results of tuberculous gland infection will undoubtedly result in more frequent resort to early radical operation.

In order to prevent recurrence of tuberculous glands of the neck, it is important to determine the cause and to remove the primary focus of infection. In a very large proportion of cases, the primary infection can be found in the tonsils or in adenoids contained in the posterior nares. It frequently happens that the tonsils became infected with tuberculosis during, or after some acute infectious disease like measles, scarlatina or diphtheria, the infectious disease having apparently made it possible for the tubercle bacilli to enter the tonsils and establish primary tuberculosis in this location. Frequently the tonsils are large and contain numerous tubercles; at other times they may be small and submerged and still contain one or more tuberculous areas. In either case they should be carefully removed. In every case of tuberculous lymph nodes in the cervical region, the tonsils and the posterior nasal space should be carefully examined for tuberculosis, and in case they are not entirely normal, they should be removed because in these cases the tonsils are practically always shown to contain tuberculous areas.

When the tuberculous lymph nodes are situated in the submaxillary region, the infectious material sometimes enters through circumscribed areas of infection around carious teeth. In all such instances the patient should employ a competent dentist to remove all dental sources of infection. It is well to guard against the further introduction of tubercle bacilli in these cases through the mouth by having these patients drink raw milk from cows that have been tuberculine tested, or if this is not possible, to have all milk properly sterilized.

Furunculosis or Boils.—Diagnosis.—The diagnosis of this condition is so evident that no space need be devoted to it. Treatment is of some importance because if not successfully handled there is tendency for the infection to extend under the deep fascia of the neck and cause deep-seated abscesses which may be of considerable gravity. In neglected cases there is also sometimes development of carbuncle or of multiple boils which reduce the health and strength of the patient decidedly.

Treatment.—If taken when in the incipient stage, boils can sometimes be aborted by the application of a mild, soothing and antiseptic ointment. An ointment with a base of equal parts of petrolatum and zinc oxide ointment and 10 grains each to the ounce of tar and salicylic acid is very satisfactory in such case. If a necrotic core has formed in a boil of considerable size it can ordinarily be handled by the application of a heavy moist antiseptic dressing; boric acid or a weak solution of bichloride of mercury (one to ten or twenty thousand) works very satisfactorily. This is really an application of Bier's hyperemia treatment. After the necrotic core has formed incision is rarely necessary for drainage. To prevent infection of the surrounding hair follicles, the skin should be thickly smeared with sterile vaseline or the antiseptic ointment which has been mentioned. In case of multiple boils the general condition of the patient needs careful attention. An abundant nourishing diet free from sugar, and tonics are important. The urine should be examined to make sure that diabetes is not present, and when it is present suitable medical treatment should be instituted as well as the surgical treatment.

Carbuncle.—In carbuncles there are usually a number of necrotic cores leading down to the site of deep infection which is located underneath the deep fascia of the neck. Energetic treatment should be undertaken early, as fatalities have resulted in neglected cases.

Treatment.—The carbuncle should be freely opened either with crucial incision or the thermocautery. In some more serious cases excision of the carbuncle is favored by some surgeons. The application of pure carbolic acid to the cut surfaces may be of some value in preventing reinfection. The cavity should be packed lightly with antiseptic gauze and a heavy moist antiseptic dressing applied, the moisture being retained by oiled muslin or silk. Attention to the general health of the patient is even more important than in furunculosis. In cases which do not readily yield to treatment an autogenous vaccine might be of some value. There is considerable difference of opinion as to the value of the stock staphylococcus vaccines which are on the market, the houses which prepare these vaccines naturally lauding their use very highly. In case an extensive raw surface is left from sloughing with a carbuncle, skin grafting is sometimes of value. Small grafts scattered over the surface do not prevent free escape of wound secretion and add a good deal to the rapidity of healing.

Abscesses.—Abscesses, cellulitis of the neck and deeply located phlegmonous processes arise from direct infections from wounds of the skin or mucous membranes, from extension of inflammatory processes in neighboring organs, for example peritonsillar abscesses and mastoid abscesses, or directly from the blood stream. In occasional rare cases an abscess apparently arises from metastasis in cases of pyemia. The diagnosis of abscess arising from continuity is usually not difficult. Where such a direct extension is not present the diagnosis may be considerably more difficult. The general symptoms of acute inflammation, considerable degree of fever beginning with or without a chill, increased number of polymorphonuclear leukocytes, swelling, deep-seated pain and tenderness make the diagnosis reasonably clear, however. Fluctuation does not appear until the abscess has worked toward the surface.

Deep-seated inflammation of the connective tissue of the upper part of the neck in the region of the salivary glands occasionally occurs.

Because of the deep location, severe pressure symptoms appear early and a fatal outcome frequently occurs unless the condition is promptly recognized and treated. This condition was first described by Ludwig in 1836 and is frequently spoken of as *Ludwig's angina.* It frequently begins with a chill followed by high fever and great prostration. Difficulty in swallowing and breathing develop early, as well as a diffuse, firm swelling in the submaxillary region which is not sharply outlined. There is a good deal of tenderness on pressure. The skin is at first unchanged, but as the inflammation develops edema appears. The patient has difficulty in opening his mouth; there is a profuse flow of saliva and the breath is extremely fetid. The presence of such inflammatory swelling in the suprahyoid region should lead to a suspicion of this trouble. Differential diagnosis from an inflammatory process extending from the floor of the mouth or periostitis of the lower jaw may sometimes have to be considered. The grave symptoms and rapid course of the disease ordinarily leave little doubt as to the diagnosis. If neglected, a fatal outcome is likely to result within a few days from general sepsis or in certain cases from edema of the larynx. In less severe cases a localized abscess may form with discharge of pus.

Treatment.—The deeper layers of fascia and aponeuroses determine the location and spread of collections of pus and hence influence the placing of incisions and drainage. Much controversy has arisen with regard to the anatomy of the deep fascia of the neck which it is not necessary to enter into at this time. If a diagnosis of deep-seated infection can be made with reasonable certainty, early drainage and free drainage are the most important considerations. In many cases the method suggested by Hilton of making a skin incision and then boring deeply into the tissues with blunt pointed forceps which are opened up when the pus cavity is located will prove of value. The surface incision may be enlarged if necessary and should be placed in the best location to drain the infection without special regard for other considerations. In avoiding important structures multiple incisions are frequently of use to freely drain deep-seated abscesses. Cigarette drains may be used or more frequently the wound is lightly packed with drainage strips. The important point is to provide free exit for the pus and unless this is accomplished there is grave danger of sepsis, of extension of the process into mediastinum, or of breaking through into the trachea or esophagus, and in rare instances there has been erosion of the walls of one of the greater bloodvessels of the neck. The general treatment of the patient should not be neglected. With this and free drainage there is usually no necessity for considering such special measures as the use of vaccines or special hyperemia devices.

Cervical Rib.—Cervical rib in and of itself may not cause any trouble and frequently is discovered accidentally. Since the publication by Keen in 1907 reporting 43 cases the attention of American surgeons has been attracted to the subject and cases have been diagnosed more frequently, however. Symptoms when present, concern usually the nerve trunks of the brachial plexus or the circulation of the subclavian artery. The sensory nerves are almost exclusively affected so that frequently the first symptom is severe neuralgic pain in the arm. In less extreme cases there is numbness, crawling or prickling sensations, and frequently a feeling of weakness or of the arm going to sleep. Usually there are no motor disturbances, paralysis having not been reported up to this date. The muscles respond less freely to electrical stimulus and in certain cases there has been atrophy of the small muscles of the hand. Hoarseness had been reported from pressure on the recurrent nerve, and Hunt has reported a case in which there was a chronic cramp-like condition of the diaphragm, which was relieved by the removal of a cervical rib from the left side. The circulatory symptoms are less troublesome as a rule than those referred to the brachial plexus. There is sometimes weakness of the radial pulse, paleness of the hands and arms, and possibly lowered surface temperature. In certain cases thrombosis has been attributed to the presence of cervical rib, also the development of aneurysm. As a rule thrombosis is developed so slowly that collateral circulation has been well established and symptoms have not been very noticeable. The subclavian artery passes over a cervical rib in the majority of cases and consequently is more superficial than usual. In some cases the rib is free and slightly movable; in other cases it is attached by bony or fibrous union to the first rib; while in other cases there is a true costal cartilage attached to the sternum. Anatomists have found the condition more usually bilateral. As a rule the rib arises from the seventh cervical vertebra, but in rare instances a sixth cervical rib has been observed. The differential diagnosis from neuritis, neuralgia, rheu-

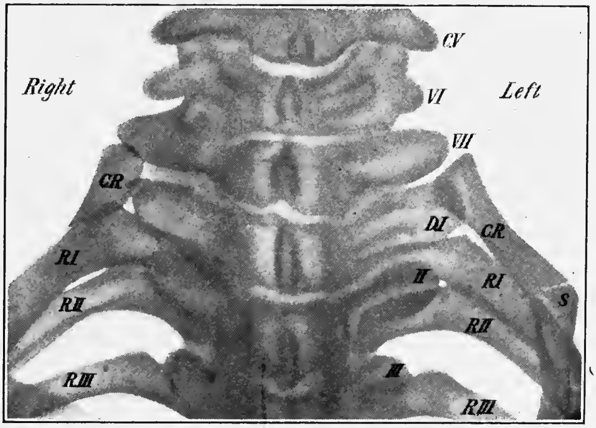


FIG. 495.—Bilateral cervical ribs. (de Quervain.)

matism or other painful conditions affecting the upper extremity is usually not difficult. In these conditions circulatory difficulties are not present nor is there any noticeable prominence. The differential diagnosis from tumors in the supraclavicular region, particularly tuberculous enlargment of the lymphatic glands, is also usually not difficult. The swelling of cervical rib is very much harder and not movable. Pain and circulatory disturbances are apt to be more constant symptoms in cervical rib than in tumors of this locality. Exostosis of the first rib sometimes gives rise to somewhat similar symptoms, but there is more likely to be pressure on the vein with edema of the arm than is the case with cervical rib. In any doubtful cases a positive diagnosis could be made by suitable x-ray examination.

Treatment.—Treatment consists in the removal of the cause; the resection of the prominent rib. An incision may be made placed along the posterior border of the sternomastoid muscle, or better, within the hair-line and joined with one parallel to the clavicle. The danger of injury to the pleura, the brachial plexus and subclavian vessels should be kept in mind. The brachial plexus is usually retracted toward the median side, undue tension of the nerve trunks being avoided with great care. The subclavian artery and vein are drawn forward. The scalenus muscle is carefully divided near its insertion and all other attached muscles are separated. The rib should *not* be removed subperiosteally as in that case recurrence is likely to follow. The pleura has been frequently torn in such operations but no serious results have followed, and if a gauze pad is quickly packed into the opening, pneumothorax does not usually result. The bone may be divided by passing a Gigli saw underneath it using care to avoid other important structures in the neighborhood. Or it may be cut with rib shears if this is found more convenient, but injury to the important surrounding structures is perhaps less easily avoided. The wound closure and dressings require no special comment. The results of the operation have been highly satisfactory in most cases.

TUMORS OF THE NECK.

Cysts of the Neck.—Diagnosis.—The various cysts of the neck have so many features in common that they may be considered most conveniently as a group. In form they are usually rounded. The size varies within the widest limits, but in general branchial, thyreoglossal and bursal cysts are relatively small while lymphatic and blood cysts are large. Even when tense with fluid they have an elastic feel and when the fluid is less tense there is sometimes definite fluctuation. These characteristics as to form, consistency and fluctuation are shared by certain lipomas, also sometimes by soft sarcomas, although the sarcomas are more frequently nodular and of firmer consistency. Certain aneurysms may also have some of these characteristics but could be distinguished by expansile pulsation. Differing from the softer malignant tumors, the growth of cysts is usually slow; is not accompanied by cachexia; and there is not metastatic involvement of distant parts of the body. From deeper seated abscesses, whether originating from caries of the cervical spine or from breaking down of the glands of the neck, the cysts can usually be distinguished by a history of inflammation, more general systemic disturbance, and usually much shorter duration. Exploratory puncture with an aspirating needle readily determines the character of the growth in the majority of cases.

The differential diagnosis of the cysts one from another is sometimes difficult or impossible, but in many cases the characteristic location is the key to the situation. For convenience the cysts may be divided into those caused by abnormal embryonic development; the retention cysts; cysts having their origin from bursæ about the larynx or hyoid bone; the blood cysts; lymphatic cysts; and those of parasitic origin, usually echinococcus.

The cysts arising from irregularities in development are sometimes further divided according to the character of their contents into serous, mucous and dermoid cysts. The location of these cysts is more or less characteristic and usually a chief factor in the diagnosis of the variety present. Many median-line growths have their origin along the course of the thyreoglossal duct, which in the early stages of embryonic development extends from the middle lobe of the thyroid to the base of the tongue. As a rule the thyreoglossal duct entirely disappears, except as a fibrous band, at about the fifth week of intra-uterine development, but in certain cases that portion above the hyoid bone persists and is spoken of as the ductus lingualis. More frequently the portion below the hyoid bone persists, sometimes forming the so-called pyramidal lobe and in other cases slowly enlarging to form a cyst, which because of its conspicuous location is usually removed while of small or moderate size. These cysts are seen in children and in early adult life, occasionally among older people. The contents are usually colorless mucous, or thin gelatinous material. Those cysts having their origin above the hyoid bone are lined with flattened entodermal epithelium, while those below the hyoid bone are lined with cylindrical, sometimes ciliated, epithelium.

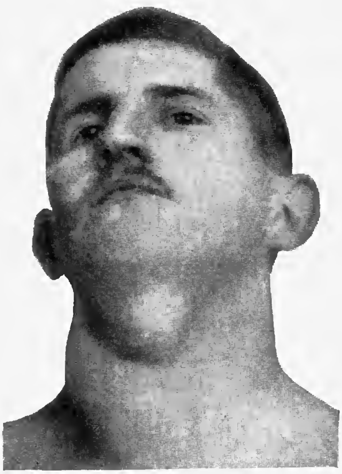


Fig. 496.—Congenital median cyst of the neck. (de Quervain.)

Teratoma or Dermoid Cysts of the Neck. — These growths are usually located on the anterior and lateral aspect of the neck corresponding closely in position to the tumors of the thyroid and also moving with swallowing. The surrounding tissues are not involved unless there has been some secondary inflammation and they are usually freely movable, painless, slow growing, and without symptoms until they enlarge to such an extent as to press upon the air passages. A positive diagnosis before removal is usually impossible. At the time of the operation the contents of the cyst indicate its character. The presence of sebaceous material, hairs and other of the usual contents of dermoid cysts is characteristic. While the tumors are ordinarily benign they sometimes undergo malignant change, which is frequently sarcomatous, and they are usually readily removed if taken before the growth has reached considerable size and has not involved surrounding tissues.

The *lateral embryonic remnant cysts* have their origin in imperfect closure of the gill slits or branchial clefts and are sometimes known as branchial cleft cysts. Like the lateral fistulæ of the neck they sometimes have their origin in a persistent thyreopharyngeal duct. The contents of these cysts may be serous, mucous, gelatinous, or may resemble the contents of a sebaceous cyst, sometimes containing cell detritus, epithelium and frequently cholesterin crystals. The lining membrane of these lateral cysts as well as the median thyreoglossal rest cysts is epithelial.

The *sebaceous retention cysts* of the skin of the neck are so common and usually so easily distinguished that it is scarcely necessary to go into the differential diagnosis in detail. Their growth is slow and symptomless; they are located in the skin and do not move on swallowing as do the branchial cleft or thyreoglossal duct cysts; their contents are characteristic sebaceous material.

The *bursal cysts* arising from the bursæ about the larynx and hyoid bone contain mucus; move with swallowing; and are usually of small size and slow development. The bursa between thyreohyoid ligament and the body of the hyoid bone is perhaps most commonly affected, and this is known sometimes as the subhyoid bursal cyst. In adults there is usually a bursa over the Adam's apple, sometimes called the antethyroid or prethyroid bursa. This is not constant; is not found with children as a rule, which together with its location might help to distinguish it from the thyreoglossal cysts. A bursa is occasionally present between the posterior insertion of the geniohyoid and genioglossal muscles, known as the suprahyoid bursa, which in rare instances gives rise to cyst formation. Injury or infection (formerly spoken of as rheumatic) or unknown causes sometimes give rise to accumulation of fluid in these bursæ. The most common are the subhyoid bursal cysts. They are usually small, for the most part painless, and are removed because of appearance only.

FIG. 497.—Congenital cystic lymphangioma of the neck. (de Quervain.)

The *blood cysts* Spannaus divides into six classes: (1) those arising from arrested fetal development; (2) those arising in the brachial cleft cysts; (3) from partial ectasis of veins; (4) from cavernous angiomas; (5) from lymphangiomas; (6) from malformations of the lymphatic glands. They may be congenital or may appear at almost any age up to fifty. They vary in size from that of a nut to that of a child's head; frequently occupy an entire side of the neck; are sometimes located under the sternomastoid muscle; and in a few cases extend into the axilla or thorax. The tension of the fluid contents is usually increased by coughing or other expiratory pressure and serious symptoms frequently arise from pressure on neighboring organs. The growth is sometimes rapid, sometimes slow, and it may remain stationary for a long time. Aspiration of the cyst contents will reveal its true character.

The *lymphatic cysts* of the neck, sometimes spoken of as hygroma cysticum colli are usually congenital or appear in the first year of life. They are usually located in the deep-lying connective tissue or in the subcutaneous fat and are very frequently found along the great vessel sheaths. Dowd has collected 91 cases from literature and considers them one of the infrequent forms of neck tumor. In certain cases the growth is rapid, pressing between all the organs of the neck, sometimes extending far down into the mediastinum. There is usually no definite limiting capsule, in distinction to embryonic rest, retention and parasitic cysts of the neck. Microscopically these cysts are lined with endothelium, and contain greatly dilated lymph vessels and lymph spaces with many outpocketings. The contents may be clear and serous, brownish if stained with blood, or a milky, cloudy fluid. The growth is apt to be slow but steady, and pressure symptoms are common.

Echinococcus cysts are among the rarest of the tumors of the neck, only 26 cases having been collected from the entire surgical literature by Guterbock in 1893. In the majority of cases they are located deeply along the sheaths of the great bloodvessels underneath the sternomastoid muscle. The growth is usually slow and in certain cases they reach enormous size even invading the thoracic cavity. Cases are on record in which fatal hemorrhage has resulted because of erosion of the great bloodvessels. Diagnosis in many cases is absolutely impossible without exploratory incision. In size, appearance, location and growth the cysts closely resemble the blood and lymphatic cysts of the neck. Even exploratory aspiration might not give the characteristic hooklets and there is nothing else in the contents of the cysts to differentiate them from certain of the blood or lymphatic cysts. The hydatid thrill which is spoken of in connection with the diagnosis of the echinococcus cysts in other parts of the body is usually absent.

Treatment.—Three forms of treatment have been suggested for the cure of cysts of the neck:

1. Aspiration and the injection of some irritating solution to destroy the secreting membrane. This method is very uncertain in its result, usually not giving a cure, and there is also danger of the injected irritant's entering communicating vessels or lymphatics. In the pre-antiseptic days it was widely used, but at present there would be few cases in which it would seem to be indicated.

2. Incision and packing of the cyst cavity may be used, but it also is uncertain in results, the cure requiring prolonged treatment, and there is risk to life from infection and sepsis even with the most careful antiseptic methods. This method might have to be employed in cases where the large vessels were eroded or in case of unusual difficulty in removing the cyst wall because of its close relation to important bloodvessels, nerves or other important structures of the neck.

3. Complete excision of the entire cyst wall is the method of choice in the vast majority of cases. In general the methods suggested under

the heading "Operations of the Neck" would apply to the treatment of these neck tumors. In a large percentage of small cysts superficially located, it is possible to excise with local anesthesia. If rupture of the cyst wall can be avoided until the dissection is complete, or nearly so, it will be of great help in removing the entire secreting membrane, but this is frequently difficult or entirely impossible. In most cases the chief difficulty is in identifying the lining membrane of the cyst, and, as an aid to the complete removal of the cyst wall, some staining fluid may be injected into the cyst cavity. Methylene blue is perhaps most frequently used. A good x-ray might be of some help in the operative removal of some of these cysts, especially those of large size. Removal of the larger cysts in the close neighborhood of the great bloodvessels and nerve trunks is often accompanied by a great deal of difficulty and danger. In some of these cases it would be much safer to leave a portion of the lining membrane of the cyst and destroy the secreting surface, if possible, by an application of pure carbolic acid or some other irritating chemical. Such treatment would be preferable to incision and packing except in case of dangerous hemorrhage where an eroded vessel communicated with the cavity.

Fig. 498. — Oculo-pupillary syndrome (Dejerine-Klumpke syndrome). Sinking in of the eye; constriction of the palpebral fissure; mycosis. From pressure on the first dorsal nerve root or the sympathetic near there.

As a rule no method of treatment except complete excision of the entire secreting surface will result in a permanent cure.

Solid Tumors of the Neck.—For convenience in discussion the solid tumors of the neck are grouped together as they have many features in common as to diagnosis and treatment. Benign and malignant tumors have to be considered. The benign tumors conform in type to the fully formed connective tissues and include those arising from the fibrous structures of the neck, from the fatty tissue of the neck, the nerves, great bloodvessels or cartilage.

All the benign solid tumors of the neck are relatively slow in growth. They do not tend to involve surrounding structures or to produce metastases. They do not as a rule produce general symptoms, especially cachexia, as do the malignant growths, and the location of some benign tumors is characteristic. While not nearly all of the benign tumors are encapsulated, encapsulation is more common than with malignant growths and, when present, is generally an indication of the benign nature of the tumor. Pressure symptoms develop late because of the slow growth of these tumors and the adaptation to their presence. Difficulty in breathing or swallowing, and hoarseness or loss of voice are, however, sometimes present in case of the deeply located benign tumors. The differential diagnosis of the various forms of benign tumors of the neck is not difficult as a rule.

Fibromas.—These are among the more common tumors of the neck and may be located either superficially or deeply. Because a number of these tumors contain a varying proportion of nervous tissue or vessels, they are sometimes classed as neurofibromas and angiofibromas, but if the nerve or vessel elements are in large amount they more properly come under the heading of neuromas and angiomas. The deep-seated fibromas of the neck sometimes take their origin from the aponeuroses of the muscles, sometimes from the periosteum of the vertebræ. These deep-seated fibromas are much more common in the posterior part of the neck, but may be found about the anterior part of the neck. In certain cases they take their origin from the fibrous tissue forming the sheath of the great bloodvessels and nerves. In such deeply-seated fibromas of the anterior surface of the neck, pressure symptoms are apt to develop relatively early. The diagnosis from the other benign tumors is usually easy because of the firmer consistency, while slower growth distinguishes them from the sarcomas.

Lipoma.—These tumors are among the most common solid tumors of the neck and they occur at every age. Depending upon the presence or absence of a limiting capsule they are sometimes classed as circumscribed or diffuse lipomas; according to location as subcutaneous or subfacial. A diagnostic point of much value when present is the dimpling of the skin when the tumor is picked up. Lobulation is also somewhat characteristic of the fatty tumors. These symptoms are not usually present with the deeply seated subfacial lipomas. The soft fluctuating feel might give difficulty in distinguishing the lipomas from the cysts or abscesses of the neck. Cystic goiter moves on swallowing, as do the cysts in the neighborhood of the larynx whether taking their origin from the bursæ about the larynx or from the thyreoglossal duct. The abscesses would ordinarily have a history of inflammatory symptoms and much more rapid development. The deeply seated subfacial lipomas may extend between the greater vessels of the neck and surround the trachea and esophagus in somewhat similar way to sarcoma. At operation, however, the attachments are usually readily separated by blunt dissection, there being no definite involvement of these tissues as with the malignant growths. A diffuse lipoma may exist in any part of the neck but occurs most commonly under the chin the so-called double chin, but diffuse masses of fat may appear at almost any place on the neck. Lobulation and dimpling of the skin are less common than with the ordinary subcutaneous lipoma.

Dissecting Lipoma.—This form of lipoma usually begins in the fatty tissue overlying the trapezius muscle. It is usually recognized at first upon the posterior surface of the neck in the middle line and advances symmetrically to the right and to the left following the fascia of the muscles of the neck and passing into the spaces between the various muscles. It may attain a thickness of 10 cm. at the point of its starting, tapering off to the right and to the left. As it passes around the front of the neck, it may follow the fascia covering the anterior muscles of the neck and pass in between these muscles. It may become so large and cumbersome as to interfere greatly with the movement of the head and with respiration.

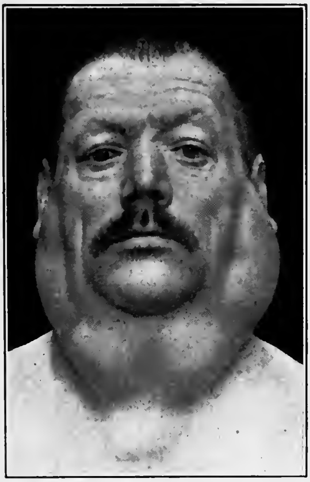


Fig. 499.—Diffuse dissecting lipoma of the neck. (de Quervain.)

Treatment.—It is usually best to remove the tumor in two sittings, because if the entire tumor is removed at one sitting in advanced cases, it is very difficult for the patient to lie in bed because of the pain caused by the extensive wound. If removed in two sittings, the patient can lie on the side opposite to which the first portion of the tumor has been removed until the wound has healed, and later he may lie on the side first operated.

Angioma. — There are two distinct classes of tumors arising from the blood-vessels of the neck. The ordinary simple angioma, nevus or birthmark, and the extensive cavernous angioma containing large blood spaces. The port wine discoloration of the skin is quite characteristic and ordinarily there is no difficulty in the diagnosis of the simple nevus. The cavernous angioma may be either superficial or deeply seated. They occur rarely in young children, most commonly with grown people, and are one of the less common tumors of the neck. In certain cases they are surrounded by a definite capsule, but somewhat more frequently, probably, there is no definite limitation to the growth. Their connection is usually with the veins although occasionally with the smaller arteries. A somewhat characteristic symptom of these tumors is the increase in size on coughing, sneezing or any other expiratory effort. It is also usually possible to decrease the size of these tumors by firm, continued pressure, the mass reappearing when the pressure is removed. With the deeply seated angiomas the diagnosis may be extremely difficult and in certain cases impossible. While the growth is usually slow it may be rapid and in certain cases gives rise to very distressing symptoms because of pressure on the trachea or larynx.

Neuroma.—The tumors of nerve origin arise either from the superficial nerve endings or from the deeply seated nerves of the neck, especially the vagus or pneumogastric. Those arising from the superficial nerve endings are among the most common tumors of the neck. There is usually a large admixture of fibrous tissue and they are sometimes classed among the fibromas. In case of the common fibroma molluscum large areas of skin and subcutaneous tissue may be involved. The skin is frequently very much thickened and pigmented, and there may be an outgrowth of hair. The appearance of these tumors is usually so characteristic that there is very little difficulty in diagnosis. Tumors taking their origin from the deep-lying nerves of the neck are among the rarest of the neck tumors. In certain cases the diagnosis would be absolutely impossible. A characteristic symptom of nerve involvement, when present, is the hoarseness or huskiness caused by the involvement of the pneumogastric nerve, and in certain cases there is difficulty in the heart's action.

Enchondromas.—These are among the very rarest tumors of the neck, only two or three cases having been reported up to this time. It is supposed that they take their origin from remnants of entodermal tissue in the neighborhood of the branchial clefts. The hardness of the growth and its characteristic location might be of some help in the diagnosis of such cases.

Treatment of the Solid Benign Tumors of the Neck.—Excision of the growth in accordance with the general principles of surgery of this locality is indicated in the majority of cases. Usually no special difficulty is encountered. The advanced fibromas are sometimes adherent to the great vessels, requiring ligation of the vessels before excision. The superficial encapsulated lipomas are usually readily excised, and even the deeply seated lipomas offer no unusual difficulties in enucleation as a rule, the outgrowth in the neighborhood of great vessels or other important deep structures being easily separated by blunt dissection. Because of the extent of the growth and the poor vitality of fatty tissue there is slightly greater danger of infection after removal of extensive diffuse lipomas. Care should be taken to secure all larger bloodvessels in the neighborhood of the fatty tumors, and in extensive growths drainage for twenty-four hours is desirable because of a tendency to ooze. Loewenthal has suggested the treatment of diffuse fatty tumors by the injection of ether and alcohol. He reports a case in which a tumor was cured by forty-two injections, but we are not aware that his suggestion as regards the treatment of these tumors has been taken up elsewhere. The simple birthmarks are perhaps most conveniently treated by carbon dioxide snow in suitable cases. Some prefer the use of the electric needle or a fine actual cautery. Excision and suture might be used in some less extensive cases and excision and skin grafting has been used in more extensive cases of this kind. The removal of certain deep-seated angiomas may be difficult or impossible because of their connection with important bloodvessels of the neck. Preliminary clamping of the large vessel trunks, as suggested by Crile might make it possible to remove certain of these tumors. The method suggested by Wyeth of injecting boiling hot water is applicable to a good many cases, and other writers have suggested the injection of carbolic acid or iodin and the use of the cautery and the electric needle in the more extensive cases. Excision of superficial neuromas is not usually attended with any particular difficulty or danger. In the more extensive fibroma molluscum it may be necessary to do extensive skin grafting. Removal of the deeply seated neuromas may be attended by considerable difficulty or danger. If they are attached to the pneumogastric nerve, resection of the nerve may be necessary. This results in difficulty in breathing and sometimes in temporary arrest of the heart action. However, the nerve has been resected in a good many cases, especially in excision of malignant glands of the neck, and without a very large percentage of fatalities. Traction on the nerve and clamping it are especially to be avoided during the operation as it may cause sudden respiratory or heart failure. Resection of the nerve gives rise to more or less permanent hoarseness because of the involvement of the recurrent laryngeal branch and sometimes a good deal of respiratory difficulty which usually clears up in time.

Fig. 500.—Malignant lymphoma of the neck. Late stage. (de Quervain.)

Malignant Tumors of the Neck.—**Carcinoma.**—The malignant tumors of the neck include primary carcinoma, metastatic carcinoma, sarcoma, and, for convenience in discussion, Hodgkin's disease, although there is doubt whether it really belongs in this group. Primary carcinoma of the neck probably arises from remnants of the branchial clefts, or in other cases takes its origin in old scars or ulcers of the skin. Primary carcinoma is not common, but secondary involvement of the glands of the neck from carcinoma in other neighboring parts of the body is of frequent occurrence. There is little difficulty in the diagnosis of carcinoma or epithelioma arising in scars or old ulcers of the neck. Malignancy may also develop in old sebaceous cysts of the neck. The carcinomas supposed to take their origin in the branchial cleft remnants are less common. A diagnosis could probably not be made with any degree of certainty as to primary carcinoma of the neck. The consistency, irregular, nodular feel, involvement of neighboring organs, rapid growth and cachexia would be very suggestive. The diagnosis of primary carcinoma from metastatic carcinoma would depend on the discovery of some primary source of disease about the face, lip, tongue, floor of the mouth, tonsils, the esophagus, trachea, nose, etc. Among the non-carcinomatous tumors there would have to be differentiated actinomycosis, or tuberculosis of the glands of the neck, or one of the forms of lymphosarcoma. A discussion of the differential diagnosis from tuberculous involvement of the glands of the neck is given in detail in that section; the diagnosis from actinomycosis under the discussion of that subject. Lymphosarcoma would be distinguished by the softer consistency, less nodular feel and less tendency to involve the skin and superficial structures. A positive diagnosis is sometimes impossible even when tissues are examined microscopically; however, if the microscopic and gross appearance are taken with the clinical history, diagnosis is usually sufficiently clear.

Sarcoma.—A number of names have been given to tumors of this class occurring in the neck. Clinically the lymphatic glands are almost invariably involved, the involvement being either multiple or affecting only a single gland or group of glands. When confined to a single gland or group of glands it is sometimes spoken of as lymphosarcoma. Formerly the Hodgkin's cases were classed among the sarcomas, although because of doubt as to cause there has been a good deal of difference of opinion. Recent studies seem to indicate that these cases belong among the infections of the glands of the neck. Clinically there is decided difference between the single and multiple lymphosarcoma of the neck. The single lymphosarcoma grows rapidly and soon breaks through the capsule, involving surrounding organs and becoming adherent to adjacent structures, eventually breaking through the skin to form large ulcerated surfaces with the outgrowth of granulations. Hodgkin's disease or malignant lymphoma, on the other hand, is at first rather slow in its development. The growth is well encapsulated; it does not involve surrounding organs; and does not infiltrate the skin or break through to become ulcerated even in the advanced stages. The growth in both cases is at first freely movable. The single lymphosarcoma grows more rapidly and the tumor is at first rounded but later becomes quite nodular and adherent to the surrounding muscles and tissues. Microscopically there is a type of sarcoma which takes its origin from the connective tissue of the glands and has the character of the simple spindle cell or alveolar sarcoma. Clinically the course of these growths is identical and a clinical distinction is impossible. Even a histological differential diagnosis is often very difficult, for large cells frequently appear in these growths, which strikingly resemble spindle cells.

Hodgkin's Disease, multiple lymphosarcoma or malignant lymphoma is characterized by a progressive hyperplasia of the lymphatic glands. It is to be distinguished clinically from tuberculosis of the glands of the neck, or carcinomatous involvement of the glands of the neck, as well as from single lymphosarcoma by the fact that the growth is strictly limited within the capsule even when extensive involvement has taken place. There is never any softening, caseation or necrotic breaking down of the gland substance as is so common in tuberculosis of the glands of the neck and as may occur with carcinomatous involvement. The disease usually appears in adolescence or early adult life, although it frequently affects children and people of more advanced age. It begins as a glandular swelling on one side of the neck without any other symptoms whatever. This swelling is slowly progressive and in the course of months it forms a somewhat nodular tumor which occupies the entire side of the neck from the jaw to the clavicle. In most cases there are no general symptoms at this time, but there is usually a rapid increase in growth with involvement of the glands of the opposite side of the neck, the axilla, the inguinal region, and in many cases the mediastinal glands. As distant groups of glands become involved general symptoms develop; the patient loses appetite and strength and becomes rapidly anemic; and in case of mediastinal involvement there is apt to be a good deal of difficulty in breathing, or in certain cases persistent cough. In some instances death results from pressure of the growth upon the trachea before general symptoms have developed or before general involvement has occurred. The diagnosis in the advanced cases is very easy because of the characteristic symptoms, but in the early stages of the disease it is absolutely impossible. The absence of any focal infection of the tonsils, mouth or skin would usually rule out simple glandular hyperplasia. The normal blood picture differentiates it from the glandular involvement occurring with leukemia. In doubtful cases excision of a gland for microscopic examination should be undertaken. Possibly the injection of material into a guinea-pig, the use of the tuberculin test, and the Wassermann reaction might be indicated. While there is nothing characteristic in the blood picture, the increase in eosinophiles may be of diagnostic significance. In the past blood cultures and examination of tissues removed have failed to show any microörganism which could be looked upon as the probable cause of the disease or as of any diagnostic value, but studies by Bunting and Yates[1] have shown a diphtheroid, non-acid-fast, Gram-staining bacillus in cultures from a number of cases; inoculation tests with monkeys later gave characteristic glandular changes. This organism is probably identical with that described by Fraenkel and Much in 1910 and Billings and Rosenow[2] have confirmed previous observations. Rosenow has isolated this organism from an abscess at the root of a tooth and from the tonsil. In the advanced stage of the disease there is sometimes fever, and the Staphylococcus aureus has been sometimes found in the blood, but this probably should be looked upon as a terminal infection and not as of any particular significance in relation to the disease.

Tumors of Carotid Gland.—Tumors of carotid gland are of relatively infrequent occurrence, although since attention has been called to these tumors in several valuable articles in recent years, the number reported has rather rapidly increased. Keen's article was the first in recent times and Randolph Winslow reported 72 cases up to September, 1916. A later paper by Lund places the total at about 100, although he does not give references for additional cases following Winslow's publication. The carotid body is located at, or just posterior, to the bifurcation of the common carotid artery. It is most fully developed in fetal

[1] Arch. Int. Med., August, 1913.
[2] Jour. Am. Med. Assn., December 13, 1913.

life, gradually disappearing later. Some believe it belongs to the sympathetic nervous system and to the chromatin group; others consider it a vascular organ or suggest analogy to the adrenals and is not a gland in the usual sense of the term, although sometimes spoken of as the carotid gland. If it persists in later life malignancy is apt to develop. Microscopically these growths are usually classed as endothelioma, or perithelioma. It is generally mildly malignant early in its development but later tends to become carcinomatous.

The first symptom noticed is usually a small oval enlargement in the superior carotid triangle, which is frequently mistaken for an enlarged lymphatic gland. Subjective symptoms are usually absent although there is occasionally radiating pain or a sense of discomfort. In most cases increase in size is slow although occasionally rapid from the start. When brought to the attention of the surgeon the growth generally has a history of several years' gradual enlargement. In adult patients it is smooth, rounded, firm and elastic, fairly freely movable laterally but not vertically. There is no expansile pulsation although this has been reported by some observers. Involvement of the cranial and sympathetic nerves is frequent in the later history of these growths, manifested by hoarseness, difficulty in speaking, from paralysis of the recurrent laryngeal nerve, or in swallowing if the glossopharyngeal nerve is involved, or by irregularity of the pulse in case the sympathetic is affected. Deafness and conjunctivitis have also been mentioned. Cachexia and anemia are present only in the terminal stages.

Diagnosis.—A diagnosis was seldom made in the earlier cases reported, but as the clinical features of this condition are better known it is being recognized with increasing frequency. The slow, steady growth differentiates it from tuberculosis of the lymphatic glands; lack of true expansile pulsation and bruit from aneurysm; its location and lack of characteristic symptoms from thyroid enlargement although aberrant thyroid and carcinoma or sarcoma of the glands of the neck are difficult of differentiation.

Treatment.—Recent writers practically all agree that early operation is advisable. In certain instances, if taken early, it is possible to dissect the tumor from the vessels without serious injury and with a reasonable prospect of freedom from recurrence. In cases of long standing there is usually such extensive involvement of important structures that closure of all three carotid vessels is essential for complete excision of the growth. All writers speak of the great vascularity of these growths and the tendency to serious hemorrhage. In the advanced cases there is serious nerve involvement in almost all. Keen found only 7 out of 26 cases free from nerve symptoms. If operated upon early it is usually encapsulated but later the extensive involvement of surrounding tissues makes necessary the sacrifice of several important nerves in many cases. In an advanced case operated upon by the writer, the hypoglossal, glossopharyngeal and lower division of the facial were all sacrificed but this patient remains free from recurrence over three years from the date of the operation. Closure of the common carotid artery alone, of course, involves serious risks, because of interference with the cerebral circulation. Up to the time of this writing, however, most of the cases reported have been so far advanced as to make the more conservative dissection from the vessels impractical so far as permanent cure is concerned. The choice lies between a high immediate mortality with good prospect of permanent cure or a much lower immediate mortality with a very high percentage of deaths from recurrence. Winslow reports 11 deaths in 34 cases, in which all three carotids were ligated and the growth excised, or nearly 33 per cent. immediate mortality. On the other hand 24 out of 25 recovered when the growth was dissected from the vessels but speedy recurrence followed in 8 cases. The temporary closure of the common carotid by Matas' aluminum bands might be tried as the band can be very readily removed in case serious cerebral symptoms arise. The closure of the vessels by suture instead of by ligature, will save at least one-half inch of the carotid artery, with correspondingly better prospect of good collateral circulation. Suture is also a safer method, especially with somewhat thickened and sclerotic vessels. This method was used in 2 cases operated upon by the writer, with an excellent permanent result in each. In a third case the growth was dissected from the vessels and radium treatment was used after healing but the growth promptly recurred in spite of this and the patient died. All writers report a high mortality. Up to the date of Lund's paper the operative mortality was estimated at 25 per cent. but with earlier diagnosis and improved methods it should be very much lower.

Treatment of Malignant Growths of the Neck.—Because of the advanced stage of the disease in which most of the malignant growths come to the surgeon the outlook for surgical treatment of any sort is most unsatisfactory. The attempt at radical removal of extensive malignant growths of the neck is followed by such very discouraging results that it would seem in the interest of surgery to refuse radical operation in the majority of cases.

Palliative Operations.—The curettement of the extensive sarcomatous or carcinomatous growths and the application of zinc chloride or other caustics frequently offers some relief from pain, bleeding and foul discharge. These measures have no permanent curative value of course. The branchiogenetic carcinomata of the neck have not as great tendency to recurrence locally, or to metastasis, as many forms of malignant growth, and, if taken early and removed thoroughly according to the general principles of operation upon the neck which have been laid down, fairly satisfactory results might be expected. In case the glands of the neck are involved secondarily, the early removal of the primary growth followed by a thorough block dissection of the neck followed by intensive *x*-ray or radium treatment has given a reasonable percentage of cures and is very well justified. In Hodgkin's disease as the growth usually begins entirely locally without any apparent involvement of surrounding organs, radical excision early would seem to be indicated. Excision later in the disease when extensive involvement has occurred is absolutely useless, so far as any hope of a permanent cure is concerned. The use of arsenic in both carcinoma and the various forms of sarcoma of the neck has long had many advocates. It may be given by the mouth in the form of Fowler's solution in doses of 5 minims three times a day, increasing 1 minim a day until 30 or 40 minims are given three times a day, then dropping back to the smaller dose and beginning over again; or the arsenate of soda granules have sometimes been used in somewhat similar manner. For many years the injection of arsenic directly into the growth has also been practised with a few

Fig. 501.—Showing result three years after excision of carotid gland tumor with extensive involvement of important structures of the neck. Paralysis of the depressor labii inferioris from section of lower filament of the facial nerve shows fairly well. See Fig. 503 (Dowd, Annals of Surgery). The carotid arteries were closed by suture instead of ligature.

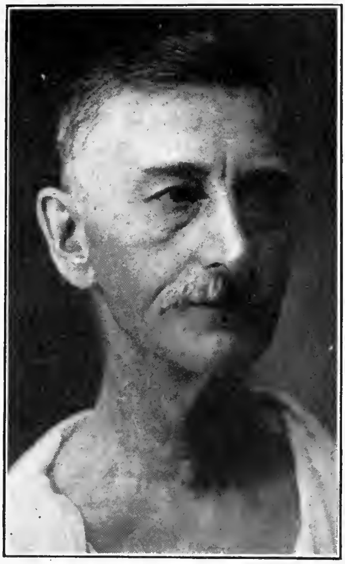


Fig. 502.—Result eight years after excision of extensive carcinoma arising in brachial cleft cyst and infiltrating great vessel sheaths, trachea and larynx. The thyroid gland was removed with the growth. The patient has received treatment with radium at intervals since the operation. The slight scar left by incision along the natural folds of the neck is also shown.

favorable results reported. Recently intravenous or subcutaneous use of salvarsan has been advocated and a number of favorable results have been reported in Hodgkin's disease. In other cases failures are reported. Very enthusiastic reports have come recently regarding the use of the x-ray in the treatment of Hodgkin's disease, but sufficient time has not yet elapsed to determine whether these results will be permanent or not. There would seem to be no objection to the use of radium or the x-ray as an after-treatment in case radical excision had been performed. Some of the results of the use of radium after radical operation have seemed to be encouraging and to warrant a further trial of this means of treatment. The use of the Coolidge tube with more accurate methods of x-ray dosage may give more favorable results in some of these cases. The vaccine of Bunting and Yates has not yet been given a sufficient trial to determine its value, but the results thus far have been favorable enough to warrant further use of this method. Billings and Rosenow report 1 apparent cure from vaccines and x-ray with improvement in 6 others. The pitiable state of many of these patients with malignant disease of the neck has led many surgeons to undertake operations in which there is little hope of permanent relief. Probably in no class of cases have more extensive and mutilating radical operations been performed and with more discouraging results. Such extensive operations which do not give permanent cures are apt to bring reproach upon surgery and should generally be discouraged.

Very encouraging reports have come from Kelly and others who have used radium in many cases, especially of sarcoma of the neck. If this form of treatment is used it seems especially important to repeat the treatment at intervals, and to keep these patients under observation for a long period of time after they have been apparently cured and to remove any remnant of the growth which may remain after the principal portion has been removed by the use of radium.

OPERATIONS OF THE NECK.

In the antiseptic preparation of the field of operation the sensitiveness of the skin of this region should be kept in mind, particularly in children who are so frequently subjects for neck operations. Too diligent scrubbing by conscientious nurses and assistants occasionally gives abrasion of the skin which amounts to a brush burn and the use of strong antiseptics not infrequently causes blistering. It is desirable in the preparation of the skin of any part of the body that the time be carefully watched in order to obtain certain results, with the fact in mind that a prolonged gentle scrub is more effectual than too vigorous shorter preparation.

The position of the patient on the table deserves consideration because it decidedly influences venous oozing. In order to get room for satisfactory work, the chin must be thrown back and if the patient is in a horizontal position this greatly aggravates venous hemorrhage. If local anesthesia or gas-and-oxygen anesthesia are used it has proved entirely safe to put the patient in a partly sitting position with the head thrown far back. If this is considered unsafe the entire table may be tilted at an angle of 20 to 30 degrees. It is surprising how much position influences the activity of venous ooze which so greatly interferes with the careful dissection. In operating in the lower triangle of the neck a small sand-bag or hard pillow between the shoulders allows the shoulder to fall back and in some cases further room can be obtained by an assistant making gentle traction downward on the arm. Throwing the head far backward not only gives a great deal more room between the chin and the sternum and clavicle, but it carries the muscles and great vessels of the neck backward making the dissection of the upper triangle very much easier. Of course the head has to be turned away from the affected side in operating upon the side of the neck.

Protection of the Field of Operation.—The operative wound is frequently located so near to the mouth that unless special measures are taken there is risk of wound contamination from coughing, vomiting or manipulations of the anesthetist. In protecting the field we have

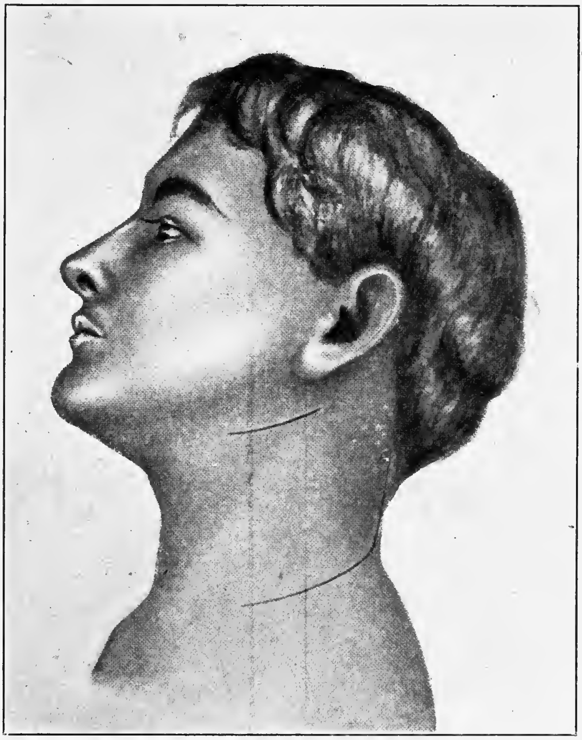


Fig. 503.—Two incisions which give access to a large part of the neck and leave little scar above the collar-line. (Dowd, Annals of Surgery.)

found the Kocher screen most satisfactory. When applied closely just under the chin it gives ample room for the operator and assistants and perfectly protects the field whatever the anesthetist may be called upon to do. A cap to hold the patient's hair in place and wet towels bound around the head help to protect the field of operation. Protective dressings may also be secured to the edges of the wound by towel clamps.

A number of plans have been suggested regarding the administration of the anesthetic so as to prevent wound contamination. With this in view some surgeons prefer the use of rectal anesthesia; others use intratracheal tubes or pharyngeal tubes inserted either through the nose or at the angle of the mouth. If the operative field is not too extensive and deeper structures are not extensively involved, local anesthesia is perfectly satisfactory in the great majority of cases, and avoids certain risks connected with any form of general anesthesia. With rectal anesthesia we have no control over the dose after the anesthetic is once administered and there is also considerable risk of bowel inflammation which would seem to contra-indicate this method in the majority of cases. There have been too many postoperative respiratory complications following the use of intratracheal anesthesia to make it seem desirable in most cases. It would seem to be definitely indicated in those rather rare cases in which there is erosion of the tracheal rings or dangerous pressure upon the air passages. Even in these cases local anesthesia is frequently perfectly satisfactory. There would seem to be no serious objection to the use of pharyngeal tubes either through the nose or introduced to the pharynx through the mouth, but if the Kocher screen is used to protect the field of operation from the anesthetist's field, there would be little use for any of these methods. With the use of the Kocher screen gas and oxygen can be used through a small mask or ether may be given by the drop method without any difficulty. In case of coughing, vomiting or difficulty in respiration the anesthetist can make all necessary manipulations without serious risk of contaminating the operative field. The method of administering ether described in the section on Surgery of the Thyroid Gland, can be used advantageously in almost all other operations of the neck.

The skin incisions in the line of the natural folds of the neck give ample room for operation in the majority of these cases. If necessary they may be combined with an incision along the posterior part of the neck within the hair-line. In case it is necessary to divide muscles in order to get satisfactory exposure of deeper structures it is desirable to place the skin and muscle incision at a different level so that there may not be a scar extending directly from the skin into the underlying muscles which draws every time the muscle contracts. This is particularly true of operations in the neighborhood of the larynx and trachea. It is also important when muscles are divided that the nerve supply should be kept in mind and it is usually possible to place the cut in such a position that the muscle is not paralyzed. Possibly the two most important applications of this principle are found with the sternomastoid which when divided a short distance above the sternum and clavicle, retains uninjured its nerve supply from the spinal accessory and spinal nerves and the sternohyoid and sternothyroid muscles which if divided near the hyoid bone leave uninjured the nerve supply from the descending loop of the hypoglossal nerve. Occasionally two skin incisions at different levels give more satisfactory exposure with less disfiguring scar than a single extensive incision. Extensive dissections along the bloodvessels are accompanied with considerable risk of bleeding which can be usually avoided if the vessels are thoroughly exposed and care is taken to secure all branches carefully and avoid undue force and the tearing of vessel walls. To prevent dangerous hemorrhage in extensive block dissections of the neck the use of temporary vessel clamps has been suggested. The experience of Crile and others has shown that such temporary compression is not harmful and that it is an efficient means of preventing serious hemorrhage in extensive neck dissections. Unfortunately in the case of many extensive growths of the neck the vessels which we would desire to secure are covered by the growth so that it is not possible to secure them before beginning the dissection. As a rule the chief essentials for successful neck surgery are time, patience and care; securing each bloodvessel between clamps before it is divided and in the case of the larger vessels immediate ligation, using two ligatures on the more important trunks. No operations in the body require a more thorough knowledge of anatomy or more painstaking care. The special risks involved in the operation for tuberculous glands of the neck will be mentioned under that heading. Securing the platysma and superficial fascia is an aid to a better result as regards the after-scar. As numerous small vessel trunks and lymphatic spaces are involved in all the extensive neck operations, drainage is usually desirable for the best results. Sometimes several twisted strands of silkworm gut inserted into one angle of wound is all that is needed. In other cases more extensive drainage with the use of tube or cigarette drains would be desirable. As a rule the drainage can be removed within the first twenty-four or forty-eight hours unless infection is present. Extensive loss of blood should be met by the use of transfusion or free use of fluid by rectum if it occurs. Patients are usually more comfortable with the head slightly raised and we frequently place them in a partial sitting position on a Gatch bed. Early removal of stitches as well as of drainage is an aid in securing better cosmetic results. The stitches may be removed as early as the first or second day following operation and the wound edges secured by the use of a collodion dressing. Usually there is considerable difficulty in swallowing following extensive dissections for two or three days, making it advisable to use a liquid diet. Dissections of the upper part of the neck frequently involve some bruising of the parotid and the patients should be cautioned that he is likely to have what looks like mumps after the operation but that it will soon disappear.

OPERATIONS ON THE LARYNX AND TRACHEA.

Five methods of attack have been used in operating for growths or diseased conditions of the larynx: (1) The endolaryngeal route with reflected light through the mouth. (2) Thyreotomy: splitting the cartilages of the larynx to get access to diseased conditions within. (3) Pharyngotomy: opening the pharynx either above or below the hyoid bone to get access to growths within the larynx. (4) Partial laryngectomy: for removal of growths involving a portion of the larynx itself. (5) Total laryngectomy; used in the removal of disease involving the entire larynx or nearly the entire larynx.

Endolaryngeal removal of many benign growths and other diseased conditions has been the preferred route by laryngologists for many years. This method of operating is available only for those who are skilled in the use of the laryngoscope, operating with the inverted image. Certain laryngologists also prefer to use this route because of the lessened danger to life in the removal of small malignant growths. General surgeons, including von Bruns, Kocher, and a number of others of high standing, condemn this method in the removal of malignant growths as offering insufficient exposure and not removing the disease thoroughly enough. This standpoint is also shared by a number of laryngologists of distinction who believe that the cures by endolaryngeal methods reported by Fränkel are the result of a coincidence of fortunate circumstances and that such cures are the unusual exception, rather than the rule. If the growth were not thoroughly removed by the endolaryngeal method, it would certainly increase the rapidity of growth and cause delay until the favorable time had passed for radical operation. With these facts in view it would seem that operation for malignant growths by the endolaryngeal method should be abandoned.

Fig. 504.—Carcinoma of the larynx. (Preysing.)

Thyreotomy.—Thyreotomy is considered by many the normal method of attack for small growths that have not caused extensive involvement. Giving complete exposure of the inside of the larynx it may be compared to an exploratory laparotomy and in case the disease is too extensive to be removed by thyreotomy alone, the more radical operation can be applied. As the field of operation is so superficial the operation can be carried out very satisfactorily under local anesthesia in many cases. About one hour before the beginning of the operation the patient is given a preliminary sedative hypodermic and is placed upon the table in the Trendelenburg position with the head hanging well over the table in order to prevent aspiration of blood. It is well to spray the larynx thoroughly with a 4 per cent. solution of cocain ten or fifteen minutes before the operation is begun in order to prevent violent coughing when the larynx or trachea is opened. If there is severe hemorrhage a preliminary tracheotomy and the use of the Hahn tampon cannula can be employed. The skin in the middle line and underlying tissues are infiltrated with novocain solution and the tissues are divided down to the thyroid and cricoid cartilage. The cartilages are then divided, opening into the larynx and retractors inserted giving complete exposure of the interior. The mucosa is swabbed with a solution of local anesthetic, either cocain or novocain and adrenalin. This not only reduces the amount of hemorrhage, but prevents reflex irritation. The diseased tissues are removed down to the cartilages, the cautery being employed in removal of malignant disease if preferred. The thyroid cartilage is stitched together, but the lower part of the wound in the neighborhood of the trachea is left open. The external wound is also closed above and a loose tampon is placed in the lower part of the incision. The breathing is usually free and it is unnecessary to use a tracheotomy tube in most cases. The voice is sometimes fairly well preserved by the formation of a scar tissue band which acts as an artificial cord. Some prefer the use of a general anesthetic in the operation for thyreotomy, but the use of local anesthesia considerably lessens the amount of bleeding and the distressing tendency to cough following operation. In case it seems necessary to use the tampon cannula because of hemorrhage or difficulty in breathing, it is usually possible to remove it at the end of the operation and replace it with a tracheotomy tube which in turn can be removed on the first or second day after the operation. Patients are usually able to swallow at the end of the first day.

Subhyoid Pharyngotomy.—Subhyoid pharyngotomy has been employed in a few cases for the removal of growths in the lower part of the pharynx and upper part of the larynx. Because of the insufficient exposure and the greater danger of postoperative pneumonia and infection it has been abandoned by most operators at present, however. As a substitute for subhyoid pharyngotomy von Hacker and Jeremitsch have recently advocated the use of suprahyoid pharyngotomy, this being suggested by the more kindly healing in cases of attempted suicide and cut throats when the cut in the neck was made above, rather than below the hyoid bone. The patient is usually placed in the Trendelenburg position with the head hanging over the table in order that blood may gravitate upward and not interfere with the breathing. Preliminary tracheotomy is recommended in the majority of cases and general anesthesia would usually be preferred. The skin incision is made above the hyoid bone extending transversely from the anterior border of the sternomastoid muscle on one side to that of the other side. In the division of the deeper muscles the geniohyoid, the mylohyoid and the digastric muscles are usually divided. The incision avoids the superior laryngeal nerve as a rule. Numerous bleeding points have to be secured before the mucous membrane is opened into the pharynx. This incision is said to give very satisfactory exposure of this region, making possible the ready removal of growths located in the upper part of the larynx or the lower part of the pharynx. The wound should be closed carefully in layers, approximating the muscles as satisfactorily as possible and provision should be made for drainage.

Partial Laryngectomy.—The operation may be either typical unilateral excision of the larynx or an atypical excision depending upon the location of the growth which is to be removed. In certain cases almost the entire larynx is removed, the operation approaching in extent a total laryngectomy. Partial laryngectomy is to be preferred to the total laryngectomy, however, in case it is possible thoroughly to remove the disease in this way because of the much better functional results, which are often surprisingly satisfactory. The patients are usually able to breathe satisfactorily without the use of the tracheotomy tube, they frequently speak in a whisper and sometimes they have considerable voice in case a scar tissue band forms which acts as a substitute for the vocal cord. Partial laryngectomy is carried out in very much the same way as thyreotomy. If the operation is extensive, however, a general anesthetic is usually necessary. In some of these cases Gluck recommends a laryngoplastic operation, using a flap of skin partially to close the air passages. If a very extensive resection is required, probably total laryngectomy would be preferable, because of the lessened danger of aspiration pneumonia. In the after-care of these patients, a tracheotomy tube is left in place for the first few days, the wound is tamponed with iodoform gauze and the patient is fed through a tube in the esophagus for the first five or six days.

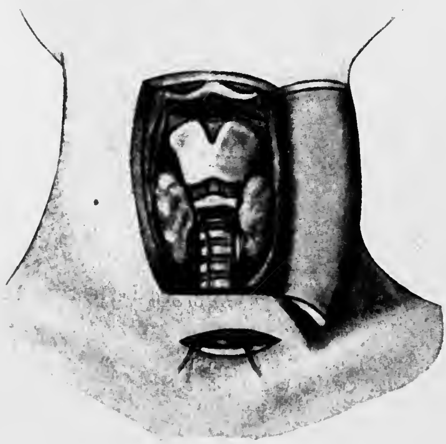


Fig. 505.—Laryngectomy. Total extirpation of the larynx. (Gluck.)

Total Laryngectomy.—Total laryngectomy is indicated in all cases of malignant disease in which eradication is impossible by less radical procedures, provided of course that the location and extent of the disease still permits of complete removal, and the general condition and strength of the patient warrants so extensive an operation. The operation as at present performed is the outgrowth of over twenty years' experience and represents, as with most important surgical procedures, contributions of many workers. The technic used by Gluck, of Berlin, probably combines the most important improvements in modern methods and includes valuable personal contributions. Gluck uses a rectangular flap to expose the field of operation, the base of the rectangle being placed toward one side and the upper limb just above the hyoid bone. He does not use preliminary tracheotomy and advises general anesthesia under chloroform. As with most operations upon the larynx the patient is placed in the Trendelenburg position with the head hanging over the table. The flap includes the skin, subcutaneous fat and platysma muscles and exposes the larynx, upper part of the trachea and superficial muscles of the neck. The sternohyoid and sternothyroid muscles are divided and drawn to one side. The superior thyroid arteries are ligated and the trachea and larynx are freed from attachment of surrounding tissues, special care being taken in the separation of the larynx and trachea from the esophagus by blunt dissection. The thyrohyoid membrane is then divided just below and parallel to the hyoid bone; the interior of the larynx and lower part of the pharynx are inspected and cocainized. A tracheotomy tube is then inserted in the larynx and sutured in place and the anesthetic is given through a tube at some distance from the operating table. As much of the pharynx is left as it possible with complete removal of the disease, in order to permit of complete closure of the pharynx over the feeding tube later. The larynx having been separated from all surrounding attachments and connection with the pharynx divided above, a longitudinal median line incision is made down to the sternal notch. The thyroid gland is then separated from the trachea, divided at the isthmus and the stumps ligated, making it possible to deliver the larynx and upper part of the trachea into the wound. Stitches having been placed with which to anchor the trachea, the larynx is divided from the upper part of the trachea and the stump is sutured into the incision just above the sternal notch. A soft rubber feeding tube is then passed through the nose and pharynx into the esophagus and the pharyngeal wound is closed with a double row of catgut sutures over which are sutured the stumps of the sternohyoid and sternothyroid muscles. The rectangular wound is then sutured at the upper and lower border and gauze is packed into the space from the side. A tracheotomy tube is usually placed in the tracheal opening and the entire neck is covered with a heavy gauze dressing. As soon as the patient has recovered from the anesthetic he is fed with liquids through the tube and should sit up as soon as possible, usually the next day after operation. Frequently the disease involves the glands of the neck, the upper part of the trachea or esophagus and sometimes the lower part of the pharynx and base of the tongue. Von Bruns reports a patient who remained well for eight years following complete laryngectomy, also removal of five upper rings of the trachea, the upper portion of the esophagus and half of the thyroid gland. When the disease involves the upper part of the esophagus, or lower portion of the pharynx and the base of the tongue, it is sometimes impossible to suture the pharynx over the feeding tube. In such cases a permanent fistula remains and Gluck feeds the patient by the use of a soft rubber funnel feeding tube introduced through the mouth and past the fistula. With this contrivance the patient is able to swallow liquids and soft diet taken by mouth. The chief cause of mortality after operations upon the larynx has been pneumonia. The complete shutting off of the trachea from the field of operation by placing the stump at the lower angle of the wound has considerably lessened this danger by preventing the aspiration of saliva, mucus, wound secretions or food. Furthermore the closure of the pharynx has also reduced the risk of wound infection and has made possible normal swallowing. By cultivating speech soon after the operation an audible and clear pharyngeal voice is sometimes gained. If this is impossible the apparatus suggested by Gluck may be used. This consists of a cap which is attached to the tracheotomy tube and which has a valve permitting inspiration. The valve closes during expiration, however, and air is carried through a small tube inserted through the nose into the pharynx. A reed in this tube makes it possible for the patient to speak, the muscles of the pharynx and the accessory sinuses performing their normal functions. Most other forms of artificial larynx have been abandoned and because of the ability to cultivate a fairly good pharyngeal voice in many cases it is unnecessary to use any artificial apparatus. It is stated that modern methods double the number of permanent cures which have resulted from operation in recent years, and that over one-third of the patients operated upon are free from recurrence. Laryngectomy, either partial or total, is also used in case of destruction of the cartilages of the larynx from inflammatory conditions and for extensive tuberculosis of the larynx which is not accompanied with serious involvement of the lungs. As to the choice of operation in case of malignancy, von Bruns states that nearly half of the patients are saved by thyreotomy if the operation is undertaken early. The immediate death-rate from total and partial laryngectomy is about equal, but the functional results of partial laryngectomy are of course superior to those of total laryngectomy. As with carcinoma of most other parts of the body the question of early diagnosis is the important one. With an early diagnosis and suitable radical operation the results are encouraging.

Tracheotomy.—Among all the operations on the air passages, tracheotomy is the most important both because of its value in saving life in emergency and as a preliminary to many of the other operations. Whenever the air passages are obstructed, from whatever cause, tracheotomy is indicated; whether from the presence of foreign bodies in the air passages; inflammatory processes, either acute or chronic, such as diphtheria, edema of the larynx, croup or tuberculosis. Also from obstruction from new growths affecting the larynx or trachea; injury of the larynx or trachea; and as a preliminary to other operations on the upper air passages. The trachea is opened in one of two locations, depending upon the conditions of the case. In the high tracheotomy, the opening is usually made through the ring of the cricoid cartilage and upper rings of the trachea, above the isthmus of the thyroid gland; in low tracheotomy, below the isthmus of the thyroid. High tracheotomy is considered the operation of choice when available, although some advise low tracheotomy for children. In many cases of emergency, the patient is unconscious and no anesthetic whatever is necessary. In case of adults, local anesthesia is perfectly satisfactory in the majority of cases. General anesthesia may be used if preferred. In case of emergency, the trachea is sometimes opened with a pocket knife and a bent hairpin or safety pin attached to a string is used as a retractor to hold the trachea open. The fact that the patients sometimes recover from such operations should not lead us to carelessness in the operation if conditions are such that the usual surgical precautions can be employed. The skin incision is made in the median line and should be reasonably ample. The sternohyoid and sternothyroid muscles should be separated from the larynx, and retracted toward either side. In a high tracheotomy the isthmus of the thyroid may need retraction downward and in case the isthmus is enlarged, it is sometimes necessary to divide it. If this is the case, it is best to crush the gland with strong forceps, something like those used by Kocher in the goiter operation and ligate the stumps to avoid hemorrhage. Sometimes a thyroid lobe also obstructs the field of operation and must either be removed or a low tracheotomy substituted. If low tracheotomy is used the isthmus of the thyroid is retracted upward instead of downward and special pains should be taken to secure large veins which are sometimes located in this vicinity. Unless the case is one of emergency the bleeding should be arrested before the air passages are opened in order that the aspiration of blood may be avoided. The trachea may be steadied by grasping the larynx between the thumb and fingers, or better by fixing it with a tenaculum; or a curved needle held in a hemostatic forceps may be used in place of a tenaculum. The wound in the trachea is widely opened using a tracheal dilator if it is available or a blunt-nosed forceps may be inserted and the jaws opened to hold the incision apart. The opening in the trachea should be large enough to permit the tracheotomy tube to be inserted easily as, if much pressure is used, there is a tendency to pushing in of the tracheal wall or the bending forward of the posterior wall of the trachea giving rise to formation of stenosis which it may be a matter of a good deal of difficulty to overcome. Obstruction through bending forward of the trachea is also caused by using too large a tracheotomy tube or one with an unsuitable curvature. To avoid this risk several tubes of different sizes should be available, suited to the particular case. Sometimes a stitch or two is taken in the skin incision, but it is usually as well to pack the wound with gauze and to apply a little moist gauze over the opening of the tube. It is desirable that air coming into the deeper air passages should be warm and moist. To accomplish this a croup kettle is sometimes used and in connection with this a bronchitis tent is sometimes placed over the patient and the steam from the kettle carried under the tent by means of a tube. A packet of gauze moistened with boric acid solution helps out somewhat in case it is impossible to have the patient inhale warm moist air. If the usual Luer double tube is used there is very little difficulty in keeping it clean as a rule. If thick mucus accumulates in the tube it is sometimes possible to remove it with a feather without taking out the inner tube. Patients are usually apprehensive in regard to their breathing when the tube is at first removed and sometimes there is more or less coughing, hoarseness and dyspnea, particularly at night, for the first few weeks after the tube is removed. Permanent disturbance of this sort is unusual and in most cases it disappears in a short time, so soon as the patients discover that their real troubles are past. Permanent difficulty in breathing is sometimes seen as the result of the accumulation of granulation tissue in the locality where the tube was placed. Hofmeister states that the prognosis in these cases is doubtful, that death sometimes results, not only in a short time but after several years as the result of persistent recurrence of granulation. He advises curetting the granulations away with a small sharp curette and cauterizing with nitrate of silver or chloride of zinc, being careful to see that none of the caustic finds its way to the trachea. Stenosis of the trachea from the bending forward of the posterior tracheal wall or from the pushing inward of curve of the trachea as has already been mentioned. If the incision into the trachea is not made strictly in the median line sometimes there is a tendency toward infolding of the edges of the tracheal incision also causing more or less obstruction. When tracheotomy is made in preparation for some further operation upon the upper air passages, the entrance of blood is sometimes prevented by wrapping a thin soft sponge about the tracheotomy tube as suggested by Hahn. Others have suggested attaching a bag of thin rubber which could be blown up by a tube so as to shut off the trachea and in this way prevent the access of blood in the lower air passages. With the patient in the Trendelenburg position and the head hanging over the end of the table there is much less trouble with aspiration of blood and the necessity for using the tampon cannula has almost disappeared in recent years since local anesthesia has more generally been employed in place of general anesthetic.

DIRECT LARYNGOSCOPY, BRONCHOSCOPY AND ESOPHAGOSCOPY.

By CHEVALIER JACKSON, M.D.

Direct laryngoscopy, bronchoscopy and esophagoscopy are procedures using electrically lighted tubes for the examination and treatment of the interior of the larynx, trachea and bronchi and the esophagus. They are performed with straight and rigid instruments, which serve as tubular specula in drawing the obstructing tissues out of the way, or by manipulating the tissues to be inspected into a new position in the line of sight. Direct laryngoscopy, besides its use for endolaryngeal examinations and operations, is a necessary preliminary to the introduction of the bronchoscope. All three procedures are used in the removal of foreign bodies and the diagnosis and treatment of disease. They are procedures free from danger if skilfully done; but like all purely manual procedures technic and dexterity are necessary. These can be acquired only by practice, a thing entirely separate and apart from the knowledge of how to do the work. To make manual dexterity effective one must acquire the ability to gauge depth and to recognize landmarks with the use of one eye only, and must further have a clear concept of the mechanical problems involved. The tubes are necessarily small, especially those for children, and the surgeon who has been accustomed to working in an open wound with both hands and both eyes will find himself at first very much handicapped. On the other hand there is nothing in any of the endoscopic procedures that cannot be safely and easily done by anyone who will devote the necessary time to practice. No amount of knowledge will lessen the necessity for practice with the eye at the endoscopic tube. It is not at all necessary that this practice be done upon a patient. The eye can be educated by the use of a bronchoscope inserted in a piece of rubber tubing, the other end of which is fixed by having a weight laid upon it upon the desk or table. Foreign bodies can be inserted in the rubber tube, the bronchoscope passed, and, by manipulation of the foreign body with the forceps, the eye can be trained not only in the intricate mechanical problems of foreign-body extraction, but the experience acquired will facilitate the recognition of the landmarks in introduction of the tubes, and, as well, aid in the recognition of pathology. It is very necessary that this training be adequate because it has been clearly proved that prolonged endoscopic procedures are dangerous while short ones are totally free from mortality if carefully done; therefore time-wasting must be eliminated, and delay minimized. In the last seven hundred cases of bronchoscopy and esophagoscopy in the author's clinic no death has resulted from the insertion of the endoscopic tube.

Instruments.—An ordinary working outfit does not contain very many instruments, neither are these very complicated, but to do good work it is absolutely essential that the outfit be adequate. Many failures and much mortality have resulted from inadequate equipment. Different sizes are necessary for adults and children. Makeshifts are impossible because of the limitations imposed upon the procedure by the necessity of using long tubes of diameter limited by the size of the natural passages. Dilatation of the natural passages is not possible here as it is in the urethra; any attempt to use an oversized instrument in the trachea, bronchi or esophagus is very quickly and inevitably fatal. The instruments illustrated in Fig. 1 are those in common use. The different sizes of tubes are not shown. The following is a list of an ordinary working outfit:

1	Jackson's adult laryngoscope.		
1	"	child laryngoscope.	
1	"	infant diagnostic laryngoscope.	
1	"	anterior commissure laryngoscope.	
1	"	bronchoscope,	4 mm. x 30 cm.
1	"	"	5 mm. x 30 cm.
1	"	"	7 mm. x 40 cm.
1	"	"	9 mm. x 40 cm.
1	"	esophagoscope,	7 mm. x 45 cm.
1	"	"	10 mm. x 53 cm.
1	"	side grasping forceps, extra light, 40 cm.	
1	"	forward grasping forceps, regular, 50 cm.	
1	"	forward grasping forceps, regular, 60 cm.	
6	"	light applicators.	
1	"	aspirator with double tube for minus and plus pressure.	
1	"	aspirating nozzle for mouth secretion.	
1	"	double circuit bronchoscopy battery.	
4	Rubber covered conducting cords for battery.		
1	Box Jackson's Bronchoscopic sponges, size 4.		
1	" " " " size 5.		
1	" " " " size 7.		
1	" " " " size 10.		
1	McKee-McCready bite-block, large size.		
1	" " " small si e.		
1	Laryngeal grasping forceps.		
1	Dozen extra lamps for lighted instruments.		

Anesthesia.—For direct laryngoscopy in children no anesthetic, general or local, is required for either diagnosis or operation upon the larynx. For adults local anesthesia may be obtained by painting the interior of the larynx with a 20 per cent. solution of cocain and if thought advisable the reflexes may be diminished by the hypodermic injection of a quarter of a grain of morphin about an hour before operation. Both morphin and cocain are dangerous in children and quite unnecessary. For bronchoscopy in children no anesthetic, general or local, is needed; older children may have a little paregoric administered if considered advisable to diminish its reflexes. The inexperienced operator will find general anesthesia of great assistance to him. However, the matter of anesthesia must be decided on the personal equation of both patient and operator. It is for the latter to decide what is best for the particular patient under the particular circumstances. For adults morphin hypodermically to diminish reflexes and cocain locally applied with the sponge holder shown at *D*, Fig. 506 are all that is necessary. Excessive dosage with morphin or other antibechic should be avoided, especially in cases with much pus. The cough reflex is the watchdog of the lungs and if not drugged asleep may be relied upon to rid the lungs of infective material.

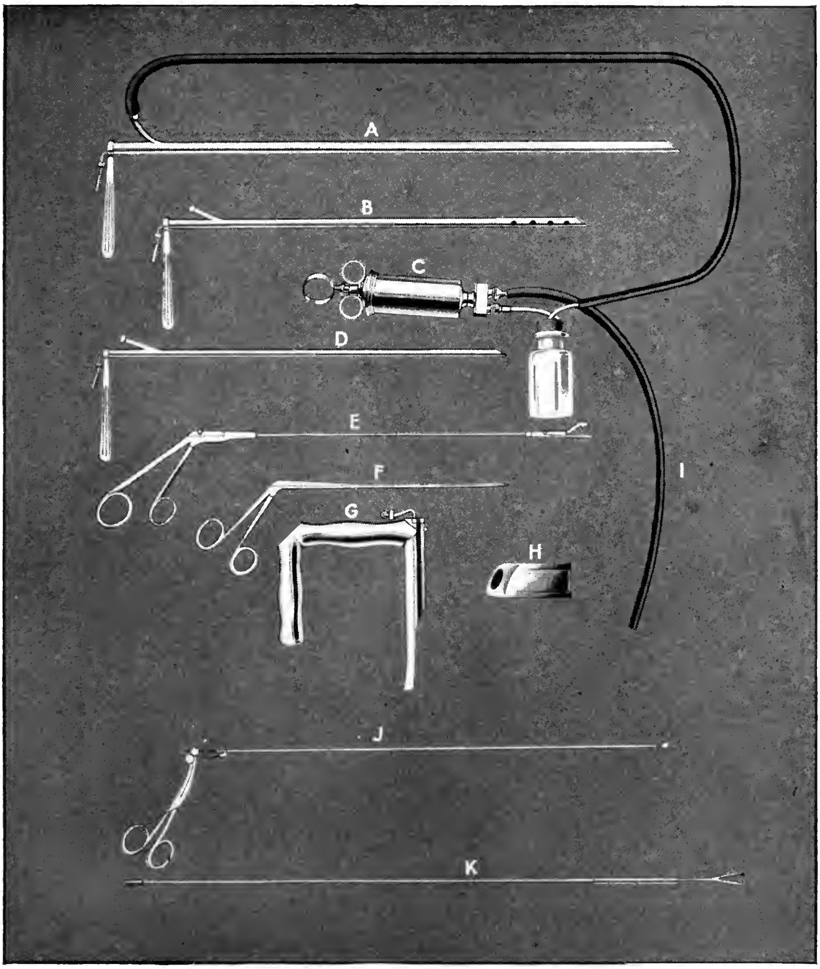


Fig. 506.—Chevalier Jackson's instruments for direct laryngoscopy, bronchoscopy and esophagoscopy: *A*, gastroscope with aspirator attached; *B*, bronchoscope; *C*, aspirator with negative pressure tube attached to gastroscope. Positive pressure tube *I*; *D*, esophagoscope; *E*, laryngeal cutting forceps for taking specimens; *F*, laryngeal grasping forceps; *G*, adult size laryngoscope; *H*, bite-block; *I*, positive pressure tube from aspirator; *J*, forceps for removing foreign bodies; *K*, sponge-carrier for sponging the field and obtaining specimens of secretion from the bronchi.

The following is the usual method of applying cocain for bronchoscopy in adults: Cocain in 5 per cent. solution is applied to the pharynx first with a gauze sponge on a sponge-carrier (*C*, Fig. 506). Then after introduction of the laryngoscope and exposure of the larynx the interior of the larynx is anesthetized by the application of a sponge-carrier which has been dipped in a 20 per cent. solution of cocain. A deeper application of the same strength is made by inserting a saturated sponge-carrier through the glottis, into the trachea and on down to the bifurcation. After the introduction of the bronchoscope the deeper air-passages and the various bronchi can be anesthetized as deemed necessary by painting with the gauze sponge held in the sponge-carrier.

Asepsis.—In view of the fact that the peroral endoscopist encounters pneumonia, diphtheria, syphilis, tuberculosis and various pyogenic infections it is wise to carry out every detail of aseptic operating-room technic so as to avoid transferring infection from one patient to another. Even the mild mouth infections to which a particular patient has become comparatively immune, may be very virulent when transferred to another individual who has not a relative immunity to that peculiar strain of perhaps a common organism. It is true that the mouth cannot be rendered aseptic; but oral antisepsis including the thorough cleansing of the teeth and gargling and rinsing the mouth with 20 per cent. alcohol will minimize septic risks. It has been demonstrated by the author that the bronchoscope introduced by the technic herein described is practically free from the probability of carrying infection to the deeper air-passages.

Position of the Patient.—In any peroral endoscopic procedure the position of the patient is of fundamental importance. The patient is recumbent for better control and ease of manipulation of the head and shoulders. For direct laryngoscopy the patient's head is upon the table; but when direct laryngoscopy is done as a preliminary to bronchoscopy the patient's head and shoulders should be out in the air as shown in Fig. 507, in order to permit of free motility of the head and neck in every direction as required in the exploration of the deeper air- and food-passages with a straight and rigid endoscopic tube. Some extension of the head is necessary to move the upper teeth out of the way but the extension must be strictly limited to the occipito-atloid joint. If the extension includes all of the cervical vertebræ as in the Rose position, the introduction of an endoscopic instrument will be exceedingly difficult. Another important difference from the Rose position is that for endoscopy it is essential that the head be held very high. The occiput should be higher than the level of the table during the start of introduction. When the tube has reached the deeper passages the head may be moved in any direction required by the operator who is following the lumen as it opens up ahead of the endoscopic tube. The position given in Fig. 507 has been worked out by long experience to facilitate the introduction of the tube. The only exception to this position is in case of a foreign body lodged in the larynx in which it is very necessary to avoid the dropping of the intruder into the deeper air passages in case the foreign body should be dislodged and not firmly grasped. The proper position for such cases is illustrated in Fig. 508.

DIRECT LARYNGOSCOPY.

Direct laryngoscopy is so called in distinction from indirect or mirror laryngoscopy. The patient being in the position shown in Fig. 507 (or in case of foreign body in the larynx, in position shown in Fig. 508) the laryngoscope is grasped in the left hand as shown in Fig. 509. The fingers of the operator's right hand are used to draw out of the way the upper lip of the patient lest the upper lip get pinched between the instrument and the upper teeth. Such an accident will cause the patient exquisite torture, whereas if pinching the lip be avoided there

Fig. 507.—Direct laryngoscopy, recumbent patient. The assistant holding the head is standing. His left hand is producing extension on the occiputo-atloid joint and at the same time raising the occiput above the level of the table. The bite-block is inserted in the left corner of the mouth, being held on the right thumb of the assistant, the palm of the hand and the extended fingers resting on the patient's left cheek to prevent rotation of the head.

is nothing in the other part of the procedure that will be painful. The introduction of the laryngoscope and the exposure of the larynx may for clearness of description as well as for promptness and effectiveness of execution be divided into two stages:

1. Exposure and indentification of the epiglottis.
2. Elevation of epiglottis and all the tissues attached to the hyoid bone so as to expose the larynx to direct view.

Stage 1.—The patient is told to open his mouth, or, in case of general anesthesia the mouth is opened and the bite-block (*G*, Fig. 506) inserted between the teeth on the left side of the patient's mouth. The

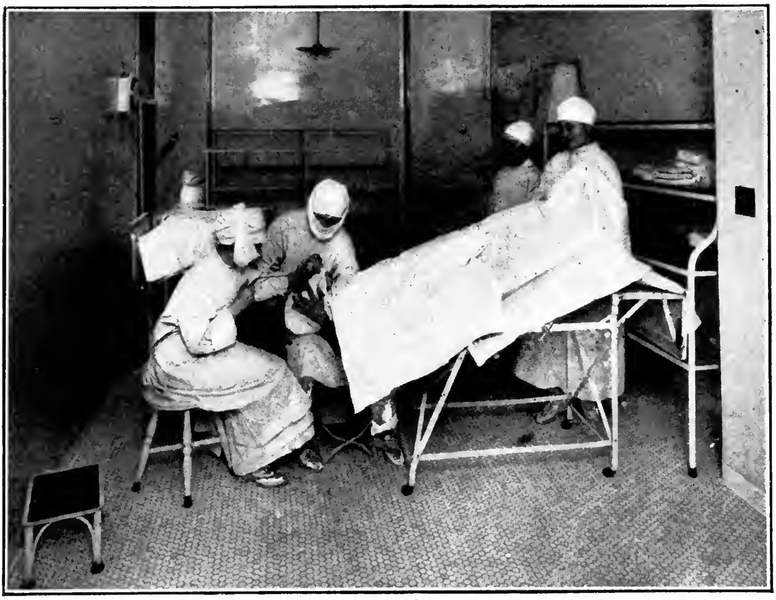


Fig. 508.—Author's position of the patient for the removal of foreign bodies from the larynx or from any of the upper air or food passages. If dislodged, the intruder will not be aided by gravity to reach a deeper lodgment.

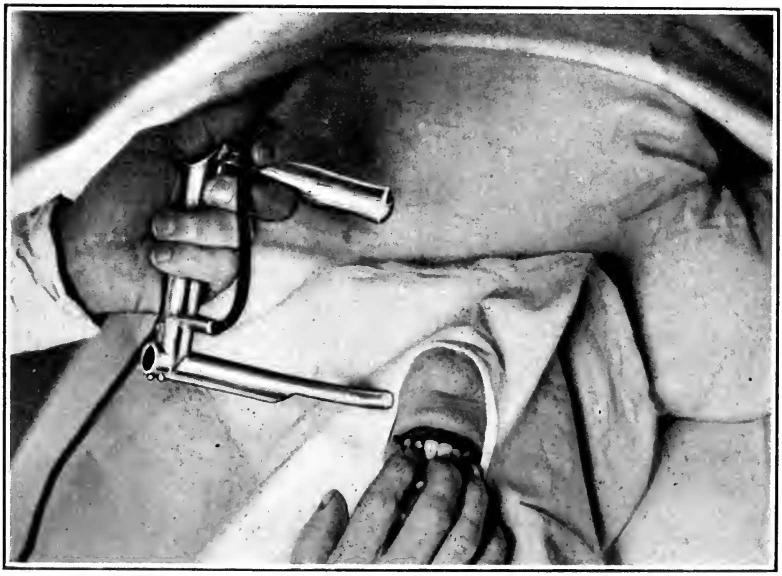


Fig. 509.—Direct laryngoscopy, recumbent patient. The laryngoscope is held in the *left* hand. The first, second and third fingers of the *right* hand are used to pull down the upper lip of the patient to prevent pinching the lip between the laryngoscope and the teeth. The camera being above the patient gives a false impression of the position of the head and chest. The chest is really very much lower than the head.

laryngoscope is passed into the patient's mouth along the right border of the dorsum of the tongue. When the posterior portion of the tongue is reached the spatular tip of the instrument is deviated toward the middle line so as to expose the epiglottis as shown at *A*, Fig. 510.

Stage 2.—The instrument is now passed about 1 cm. deeper, the spatular tip passing posterior to the epiglottis and immediately a lifting action is exerted with the spatular tip as if the effort were being made to suspend the head by lifting upon the hyoid bone with the spatular tip of the instrument. If the larynx is not at once exposed it is probable that the instrument has been inserted too deeply. If so a slight withdrawal is necessary to again bring the epiglottis into view when the procedure of lifting is again exerted. Great care is necessary to avoid the great natural tendency of the operator unconsciously to lower his head and to get lower and lower himself. This must resolutely

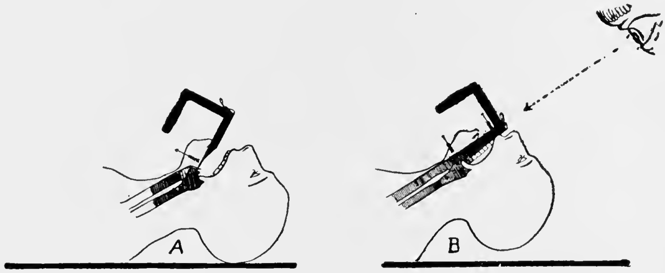


Fig. 510.—Schema illustrating manner of exposure of the larynx with the direct laryngoscope. At *A* the laryngoscope has been inserted posterior to the dorsum of the tongue until the epiglottis has come into view. The laryngoscope is then inserted about 1 cm. deeper, the spatular tip going posterior to the epiglottis. A strong lifting motion is now exerted in the direction of the dart, even lifting the patient's head from the table as shown at *B*. The glottis and the tracheal axis thus are brought in line with the observer's visual axis.

be resisted and the object always kept in mind of *lifting* the patient's head and neck upward so that the operator can see into the larynx without bending over. In other words lifting the laryngoscope up to a point where the operator's eye can see through it into the larynx. This is necessary to avoid the fundamental error of trying to pry open the larynx by using the upper teeth as a fulcrum. When the larynx first comes into view the cords are not visible because of the spasmodic, tight closure of the ventricular bands. The patient is told to take a deep breath. As soon as he does so the glottis opens and the cords are visible on each margin. Of course if the patient is under a general anesthetic he cannot be told to take a deep breath; but if he be so deeply anesthetized that the reflexes are abolished the glottis will remain open for respiration.

Removal of Foreign Bodies from the Larynx by Direct Laryngoscopy.—Having exposed the larynx in the manner described the foreign body is searched for and when found the portion of it to be seized is determined according to the size, shape and surface of the foreign body. Pointed foreign bodies should always be seized at or as close to the point as possible and the point is then freed from the tissues before removal. In the case of transfixed foreign bodies great care is necessary not to lacerate the larynx by pulling them out crosswise. They should be seized, as in the case of pointed foreign bodies, near one end if neither end be pointed. Foreign bodies in the subglottic space should be very carefully disimpacted and brought out with their greatest diameter corresponding to the sagittal plane. Great care should be taken not to lacerate the cords and not to injure the crico-arytenoid joint, either of which accidents may seriously impair the voice. Severe trauma may cause edema, later, perichondritis, either of which may cause so much stenosis as to require tracheotomy. Care in the manipulations will avoid such complications.

Direct Laryngoscopy for the Removal of Laryngeal Growths and Specimens.—For the differential diagnosis of diseases of the larynx, such as lues, malignancy and tuberculosis, it is often necessary to remove a specimen of tissue for biopsy. For this purpose direct laryngoscopy is invaluable because of the accuracy with which the specimen can be removed from precisely the location desired. It is advisable to remove the margin of the growth or ulcer so as to include a small portion of the normal mucosa in order that the histologist may see the transition. If the case prove to be one of malignancy it is perhaps not so serious a matter if the voice be impaired; but if the case should prove to be one of tuberculosis or lues it is a misfortune to have injured the voice by damaging the cords or the motor area of the larynx. Therefore, whenever possible some area other than these should be selected for the removal of the specimen. For the removal of specimens the cutting forceps (*E*, Fig. 506) are best.

The Removal of Benign Growths from the Larynx by Direct Laryngoscopy.—Benign growths such as papillomata can be removed with great accuracy by the direct method and such removal usually results in a prompt restoration of the voice, if, as is usually the case, the growth has been interfering with clear phonation. The best forceps for this purpose is one having crushing jaws rather than cutting jaws, because the papillomata are very small, resembling venereal warts in character. They are very readily crushed off and the difference between the sound tissues and a papilloma is very promptly noticed by the trained touch. Since papillomata are very prone to recur, radical operation is contra-indicated. It is very unwise to remove the base deeply. The recurrence is essentially different from the recurrence of malignancy. Papillomata do not infiltrate the basal tissues and very often a "recurrence" is in the form of an entirely new growth in a new location. No matter how radically a papillomatous mass may have been removed from one cord such removal can in no way prevent recurrence at another site, for instance the opposite ventricular band, and to have damaged the cord by radical removal of the base is a great and avoidable misfortune. The best ultimate vocal results are obtained from very neatly and precisely removing the protruding portion of the papillomatous mass flush with the surface of the mucosa, with subsequent removal of "recurrences" as they appear, until the time arrives when the tendency to recurrence or repullulation ceases. Ultimately from many removals or from some other cause the tendency to recur disappears. Benign growths other than papillomata usually do not recur, after complete and precise removal by direct laryngoscopy.

Direct Laryngoscopy for the Introduction of Intratracheal Insufflation Anesthesia Tubes.—The insufflation catheter can be inserted in the trachea by anyone who will take the time to practice the details mentioned under the heading of Direct Laryngoscopy. The catheter could be introduced in any patient without any anesthesia, general or local, by those who have acquired the knack; but inasmuch as the patient it to be anesthetized anyway he should be placed *deeply* under the ether by the open method before any attempt is made to insert the insufflation catheter. This abolishes the laryngeal reflex and relaxes the muscles of the neck in a way that makes it very easy to expose the larynx if the anesthetist follow the instructions as to *lifting* the patient's head off of the table by the hyoid bone with the tip end of the laryngoscope passed posteriorly to the epiglottis before the lifting motion is commenced, as seen in Fig. 510 and Fig. 522. The following rules should be carefully observed:

1. The patient should be fully under the anesthetic by the open method so as to get full relaxation of the muscles of the neck and abolition of the pharyngeal and laryngeal reflexes.

2. The patient's head must be in full extension with the vertex firmly pushed down toward the feet of the patient, so as to throw the neck upward and bring the occiput down as close as possible beneath the cervical vertebra; but it is essential to remember that the extension must be only at the occipito-atloid joint and that the patient's head must be lifted off the table. Extension with the head lower will mean a curvature of the cervical vertebra which will defeat the object entirely. The head must be high.

3. No gag should be used, because the patient should be sufficiently anesthetized not to need a gag, and because wide gagging defeats the exposure of the larynx by jamming down the mandible upon the larynx.

4. The epiglottis must be identified before it is passed.

5. The laryngoscope must pass sufficiently far below the tip of the epiglottis so that the latter will not slip away.

6. Too deep insertion must be avoided, as in this case the laryngoscope goes posterior to the cricoid, and the cricoid is lifted, exposing the mouth of the esophagus, which is bewildering until sufficient education of the eye enables the operator to recognize the landmarks.

BRONCHOSCOPY.

Introduction of the Bronchoscope.—The essentials for the quick and skilful introduction of the bronchoscope are two, namely:

1. Adequate exposure of the glottis by direct laryngoscopy.

2. Correct position of the patient. With practice it should not require more than from thirty to fifty seconds to introduce the bronchoscope in any patient whose mouth can be opened, and this can be done in children without any anesthesia, general or local. In adults introduction need require no longer except for the time required for the painting on of a local anesthetic. The glottis having been exposed in the manner described under "Direct Laryngoscopy" the bronchoscope, illuminated with its own separate cord from the bronchoscopic battery, is intro-

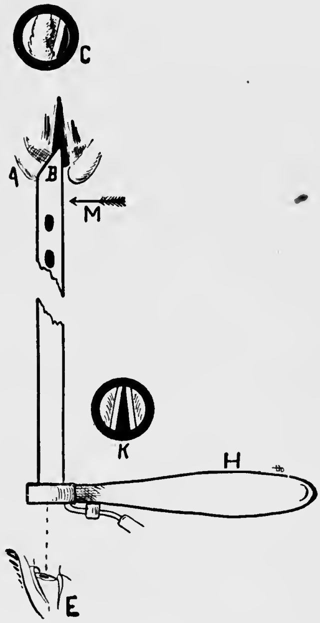


Fig. 511.—Schema illustrating the introduction of the bronchoscope through the glottis, recumbent patient. The handle, *H*, is always horizontally to the right. When the glottis is first seen through the tube it should be centrally located as at *K*. At the next inspiration the end, *B*, is moved horizontally to the left as shown by the dart, *M*, until the glottis shows at the right edge of the field, *C*. This means that the point of the lip, *B*, is at the median line and it is then quickly (not violently) pushed through into the trachea. At this same moment or the instant before, the hyoid bone is given a quick additional lift with the tip of the laryngoscope as shown by the dart (Fig. 512). In the sitting patient everything is the same except that the laryngeal image is reversed sagitally and laterally.

duced into the laryngoscope. The bronchoscopist's eye is now transferred to the bronchoscope and the glottis found again. The bronchoscope must always be introduced in the position shown in Fig. 511, the handle being out to the right as shown at H. As soon as the bronchoscopic tube mouth has entered the trachea care is taken to be sure that the bronchoscope is introduced not farther than 3 cm. The heavy laryngoscope is then removed by axially rotating it sidewise and removing the slide, leaving only the light bronchoscopic tube in position as shown in Fig. 514. Before removing the laryngoscope it is necessary to be certain that the bronchoscope is in the trachea. There are times when the bronchoscope seems to have a tendency to slip into the

Fig. 512.—The operator is lifting upward strongly with the laryngoscope as though suspending the head and neck structures by the hyoid bone. Care should be taken not to use the teeth as a fulcrum and try to expose the larynx by wedging the tip of the laryngoscope upward. The bronchoscope is about to be introduced. Note the position of the handle toward the right.

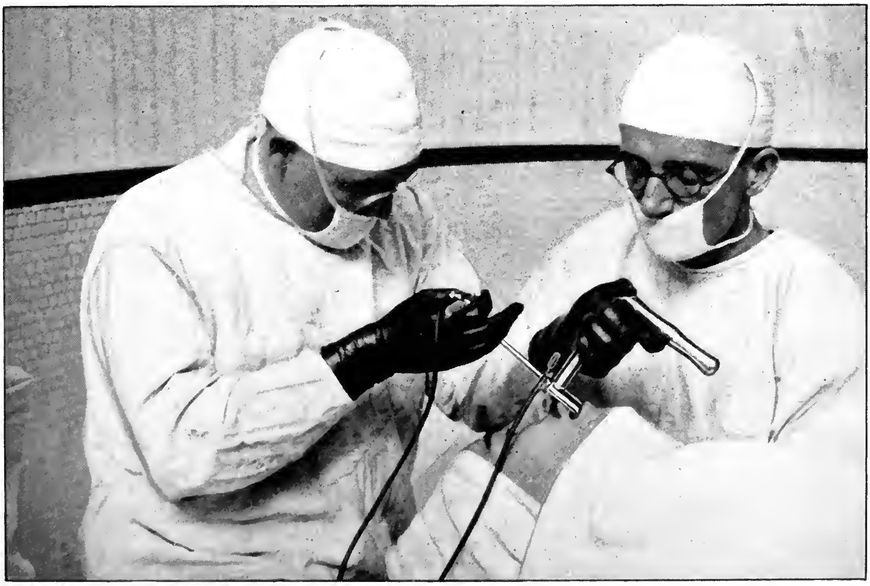


Fig. 513.—Insertion of the bronchoscope. Note direction of the trachea as indicated by the bronchoscope. The patient's head is held above the level of the table. The assistant's left hand should be at the patient's mouth holding the bite-block. This is removed and the assistant is on the wrong side of the table in the illustration in order not to hide the position of the operator's hands. Note the handle of the bronchoscope is to the right.

esophagus. The identification of the trachea is very readily done when the trachea is not inflamed because the rings show out clearly. If the mucosa is edematous the rings may be obliterated. A strong blast of air usually comes up through the bronchoscope in an unmistakable way, but it must be remembered that the bronchoscopist may be deceived by the "breathing" of the esophagus apparent when a tube is inserted in it owing to the alternate negative pressure during inspiration. This breathing, however, is usually associated with a bubbling, spluttering sound that is unmistakable once it is heard. One of the most

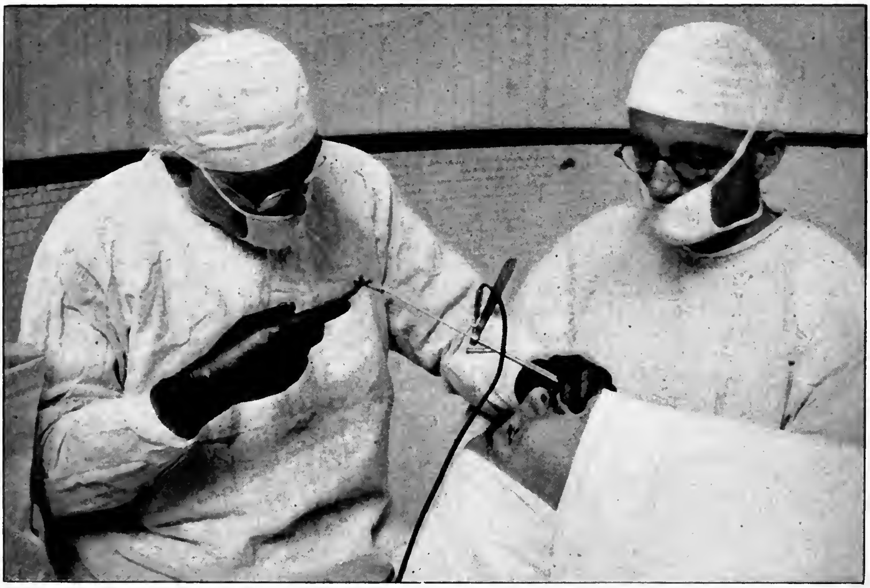


FIG. 514.—The heavy laryngoscope has been removed leaving the light bronchoscope in position. The operator is inserting forceps. Note how the left hand of the operator holds the tube lightly between the thumb and first two fingers of the left hand, while the last two fingers are hooked over the upper teeth of the patient "anchoring" the tube to prevent it moving in or out or otherwise changing the relation of the distal tube-mouth to a foreign body or a growth while forceps are being used. Thus, also any desired location of the tube can be maintained in systematic exploration. The assistant's left hand is dropped out of the way to show the operator's method. The assistant during bronchoscopy holds the bite-block like a thimble on the index finger of the left hand, and the assistant should be on the *right* side of the patient. He is here put wrongly on the left side so as not to hide the instruments and the manner of holding them.

important ways to identify the trachea is that the tube stands open whereas the esophageal image is more or less made up of collapsing folds. In the exploration of the tracheobronchial tree the next landmark is the bifurcation of the trachea which is located by "weaving" the bronchoscope from side to side. This is necessary because the bronchoscope is much smaller in diameter than the trachea. If it were not it could not enter either bronchus. Usually it is better to have the patient's head a little bit to the right and the handle, *H*, Fig. 511, now turned to the left. This brings more naturally into view the left bronchial orifice. Needless to say it is necessary to see both bronchial orifices in order to see the bifurcation between them and a lost carina is usually a lost left bronchial orifice, because morphologically the right bronchus is the normal continuation of the trachea and the bronchoscope goes on down into it without the observer having seen the left bronchial orifice at all, unless particularly searched for. Having located the carina the right upper lobe bronchus is next exposed. This is done not by deeper insertion of the bronchoscope but simply by the strong swinging of the head to the left with the bronchoscopic tube-mouth at the carina. The upper lobe bronchus is given off practically at the bifurcation so far as endoscopic appearances are concerned. The next important landmark is the middle lobe bronchus which is seen by turning the handle, *H*, upward so as to bring the lip, *B*, upward, the patient's head at the same time being dropped. This brings into view the anterior wall of the stem bronchus. The middle lobe bronchus comes off anteriorly and the spur between the middle lobe bronchus and the inferior lobe bronchus is a horizontal one. The stem bronchus below the middle lobe bronchus will be seen to give off dorsal and ventral as well as lateral branches. Returning to the carina which is our first landmark in the lower air-passages the bronchoscopic lip is turned to the left, the patient's head moved over to the right and the bronchoscope inserted into the left main bronchus. The upper lobe bronchus in the adult is given off about 2 to 3 cm. down from the carina. The orifice is exposed by strongly bending the head and neck of the patient to the right. The left upper lobe bronchus does not go off directly laterally but somewhat anteriorly so that the spur between it and the orifice of the inferior lobe bronchus is at an angle of about 45 degrees with the horizontal. The left inferior lobe bronchus gives off dorsal and ventral branches very similar to those on the right side except for the one large posterior branch which is very frequently invaded by foreign bodies. The upper lobe bronchi on either side cannot be entered so as to present a lumen image. Only the orifices and a small portion of the lumen of the branch bronchi below can be seen. The main portion of the upper lobe bronchi are "around the corner." Fortunately they are exceedingly rarely invaded by foreign bodies; otherwise bronchoscopic removal would be not so uniformly successful.

Bronchoscopy for Disease.—Lung abscesses can be entered with the bronchoscope and drained. In case of abscesses secondary to foreign bodies a cure results almost invariably from the dilatation of the orifice of the abscess and the removal of the foreign body. In lung abscess due to other causes bronchoscopy has so little to offer that external operation should not be delayed. Why this difference should exist remains to be investigated. Be the cause what it may there can be no question as to the clinical facts. Of 36 cases of lung abscess secondary to foreign body in the author's clinic, 34 are alive and well today, with perfectly normal lungs as the result of the peroral bronchoscopic removal of the foreign body. Bronchiectasis presents almost a parallel. Bronchiectatic conditions not due to foreign body have been treated by endobronchial lavage and local medication with a degree of success that indicates that further effort in this direction is well worth while. On the other hand bronchiectatic symptoms secondary to foreign body have totally disappeared following the removal of the foreign body, in every case.[1]

While the removal of esophageal secretion is readily accomplished by the drainage canal and negative pressure pump, it has been found that bronchial secretions are often too thick and viscid to pass readily through a drainage canal, which must necessarily be small. Because of this, the sponge pumping system was evolved by the author; this consists of inserting a properly sized and folded gauze sponge on a long Coolidge sponge-carrier through the bronchoscope so that it emerges from the tube mouth. The patient is then asked to cough, following which the sponge-carrier is withdrawn, bringing with it the secretion which the patient has coughed into the tube.

Bronchoscopy for Foreign Bodies.—The introduction of the bronchoscope may be very quickly mastered by anyone who cares to devote the necessary time to the manual practice of the details of introduction. When, however, we come to the mechanical problems of the withdrawal of a foreign body we have a totally different matter. The most intricate and involved mechanical problems may try to the utmost the technical and especially the mechanical skill as well as the patience of the bronchoscopist. It is only by the greatest carefulness that trauma can be prevented and it is only by the manipulation of the foreign body in such a way that points will not become entangled in branch bronchi nor buried in the mucosal wall that fatal trauma can be avoided. It is absolutely unjustifiable to seize and grasp any portion of a foreign body as soon as seen. The situation of the intruder must be studied and the proper position for the application of the forceps determined. All of this must be done without delay since prolonged bronchoscopies in children are exceedingly dangerous. For the successful solution of these complicated mechanical problems it is absolutely essential that the bronchoscopist shall practice long and carefully in a rubber tube so as to develop to the utmost the fine manual skill by which he is able to execute exceedingly complicated manipulations by coördinate control of the lip of the tube-mouth and the forceps. He soon acquires a habit of using these together just as one uses a knife and fork. He can turn a foreign body around end for end, doing a "version;" an unfavorable presentation can be converted into a favorable one for seizure; the lip can be used to make counterpressure upon the tissues while the forceps are disembedding the point of a foreign body. All of these procedures can be done with perfect safety to the patient provided the bronchoscopist has deemed it worth while to practice the procedures and provided the time limit of the first bronchoscopy is not exceeded. Even the specialist in bronchoscopy does not get sufficient

[1] Chevalier Jackson: Bronchiectasis and Bronchiectatic Symptoms Due to Foreign Bodies, Penna. Med. Jour., August, 1916, xix, 807–814.

practice upon the patient because his bronchoscopies in each case, are generally limited to the few minutes usually necessary to remove the

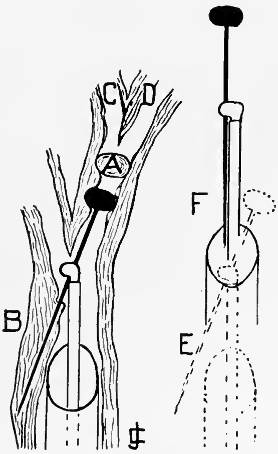


FIG. 515.—Schema illustrating the mechanical problem of extracting a pin, a large part of whose shaft is buried in the bronchial wall, *B*. The pin must be pushed downward and if the orifice of the branches, *C*, *D*, are too small to admit the head of the pin some other orifice (as at *A*) must be found by palpation (not by violent pushing) to admit the head, so that the pin can be pushed downward permitting the point to emerge (*E*). The point is then manipulated into the bronchoscopic tube-mouth by means of coördinated movements of the bronchoscopic lip and the side-curved forceps, as shown at *F*.

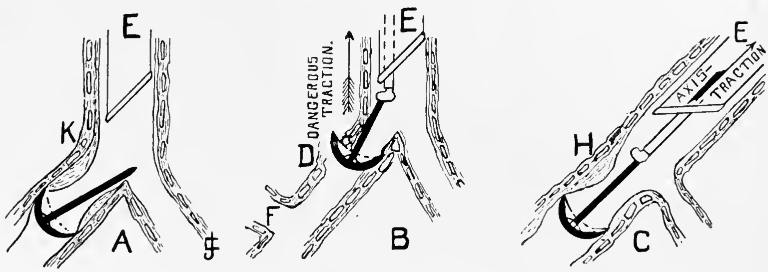


FIG. 516.—Schema illustrating the "mushroom anchor" problem of the brass-headed upholstery tack. At *A* the tack is shown with the head bedded in swollen muscosa. The bronchoscopist, looking through the bronchoscope, *E*, considering himself lucky to have found the *point* of the tack, seizes it and starts to withdraw it, making traction as shown by the dart in drawing *B*. The head of the tack catches below a chondrial ring and rips in, tearing its way through the bronchial wall (*D*) causing death by mediastinal emphysema. This accident is still more likely to occur if, as often happens, the tack-head is lodged in the orifice of the upper lobe bronchus, *F*. But if the bronchoscopist swings the patient's head far to the opposite side and makes *axis-traction*, as shown at *C*. the head of the tack can be drawn through the swollen mucosa without anchoring itself in a cartilage. If necessary, in addition, the lip of the bronchoscope can be used to repress the angle, *K*, and the swollen mucosa, *H*. If the swollen mucosa, *H*, has been replaced by fibrous tissue from many months' sojourn of the tack, the stenosis many require dilatation with the divulsor.

foreign body. It is therefore necessary for everyone to educate the eye and the fingers by work with the bronchoscope manipulating and removing a foreign body previously inserted in a piece of rubber tubing which serves as a manikin. In it all sorts of mechanical problems can

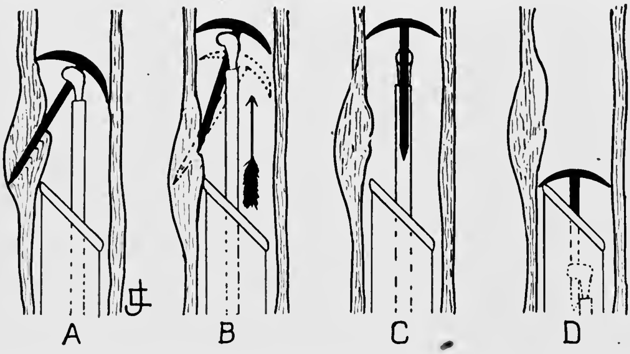


FIG. 517.—Problem of theupholstery tack with buried point. If pulled upon, the imminent perforation of the mediastinum, as shown at *A*, will be completed, the bronchus will be torn and death will follow even if the tack be removed, which is of doubtful possibility. The proper method is gently to close the side curved forceps on the shank of the tack near the head, push downward as shown by the dart, in B, until the point emerges. Then the forceps are *rotated* to bring the point of the tack away from the bronchial wall. It is usually better at this stage to release the tack and grasp it firmly near the point for withdrawal, *D*. During stages *A*, *B* and *C* the tack is grasped very gently.

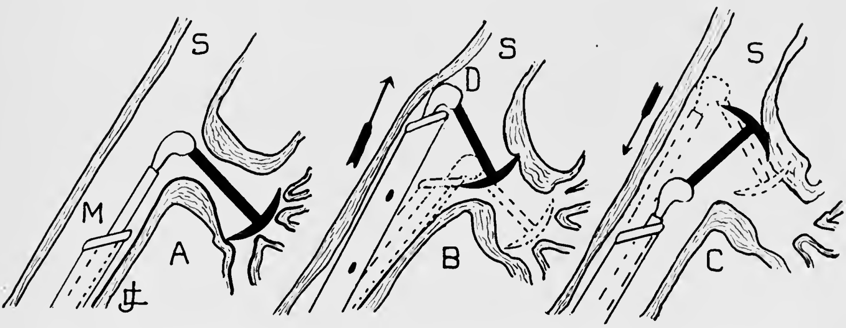


FIG. 518.—Schema illustrating the "upper-lobe-bronchus problem," combined with the "mushroom-anchor" problem and the author's well-tested method for their solution. The patient being recumbent, the bronchoscopist looking down the right main bronchus, *M*, sees the point of the tack projecting from the right upper lobe bronchus, *A*. He seizes the point with the side-curved forceps then slides down the bronchoscope to the position shown dotted at *B*. Next he pushes the bronchoscopic tube-mouth downward and medianward, simultaneously moving the patient's head to the right, thus swinging the bronchoscopic lever on its fulcrum, and dragging the tack downward and inward out of its bed, to the position, *D*. Traction, as shown at *C*, will then safely and easily withdraw the tack. A very small bronchoscope is essential. The *lip* of the bronchoscopic tube-mouth must be used to pry the forceps down and over, and the lip must be brought close to the tack just before the prying-pushing movement. *S*, right stem-bronchus.

be simulated. A few of the solutions of mechanical problems are illustrated in Figs. 515 to 521 inclusive.[1] In all of these manipulations

[1] For further study of this subject the reader is referred to "Peroral Endoscopy," textbook by Chevalier Jackson.

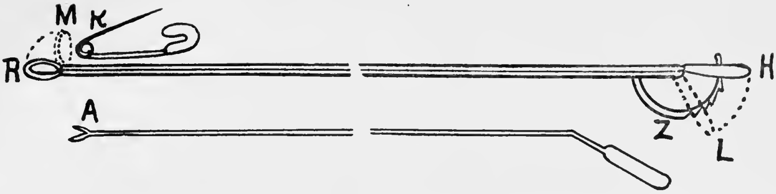


FIG. 519.—Schema illustrating the endoscopic closure of open safety pins lodged point upward. The closer is passed down under ocular control until the ring, *R*, is below the pin. The ring is then erected to the position shown dotted at *M*, by moving the handle, *H*, downward to *L*. and locking it there with the latch, *Z*. The fork, *A*, is then inserted and, engaging the pin at the spring loop, *K*, the pin is pushed into the ring, thus closing the pin. Slight rotation of the pin with the forceps may be necessary to get the point into the keeper.

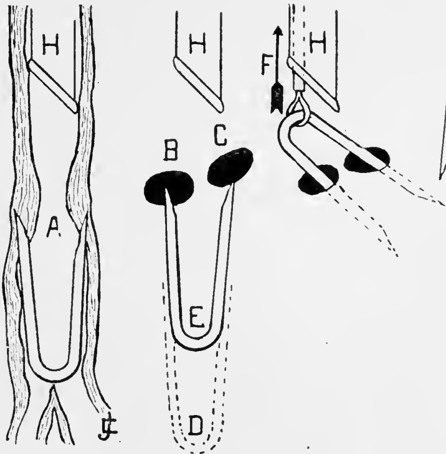


FIG. 520.—Schema illustrating a new method of removal of bronchially-lodged staples or double-pointed tacks. *H*, bronchoscope. *A*. swollen mucosa covering points of staple. At *E* the staple has been manipulated upward with bronchoscopic lip and hooks until the points are opposite the branch bronchial orifices, *B*, *C*. Traction being made in the direction of the dart (*F*), by means of the rotation forceps, and counterpressure being made with the bronchoscopic lip on the points of the staple, the points enter the branch bronchi and permit the staple to be turned over and removed with points trailing harmlessly behind (*K*).

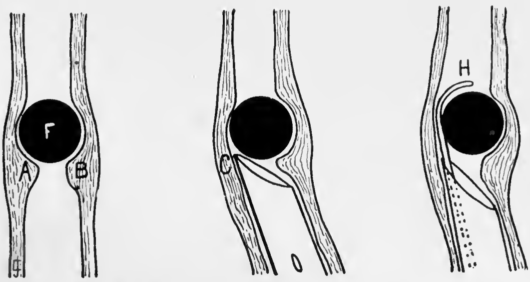


FIG. 521.—Schema illustrating the use of the lip of the bronchoscope in disimpaction of foreign bodies. *A* and *B* show an annular edema above the foreign body, *F*. At *C* the edematous mucosa is being repressed by the lip of the tube-mouth, permitting insinuation of the hook, *H*, past one side of the foreign body, which is then withdrawn to a convenient place for application of the forceps. This repression by the lip is often used for purposes other than the insertion of hooks. The lip of the esophagoscope can be used in the same way.

it is necessary to keep in mind that if no harm is done the bronchoscopy can be repeated any number of times. Therefore it is absolutely unjustifiable to take the risk of pulling out a foreign body not free to move and from which the tissues cannot be protected in the position in which it is found. While it is undoubtedly true that if allowed to remain the foreign body will prove fatal it will not prove fatal within weeks or even months. Only too often in the early days of the work death promptly followed the ruthless tearing out of an entangled foreign body on the assumption that it would prove fatal if allowed to remain. The motto should be, "Don't kill your patient; if you do you cannot try again."

Fig. 522.—Insufflation ether anesthesia with the Elsberg apparatus in the clinic of Dr. Otto C. Gaub. The anesthetist, Dr. Wade Elphinstone, has exposed the larynx and is about to introduce the silk woven catheter in a case of head surgery. Note the full extension with the head on the table and the relatively high position of the head.

Mortality and Results of Bronchoscopic Foreign Body Extractions.—In the last 300 consecutive cases of foreign body in the air-passages the intruder has been endoscopically removed bloodlessly through the mouth in 98 per cent. of the cases. There has been no death directly attributable to the endoscopic procedure. There were only three deaths from any cause whatever within thirty days after the bronchoscopy and this included cases which came in in very serious condition. The mere passage of a bronchoscope is unassociated with any mortality if considered entirely apart from the condition for which it is done. Undoubtedly the mortality encountered in the early days of the work was due to failure to recognize the danger of prolonged

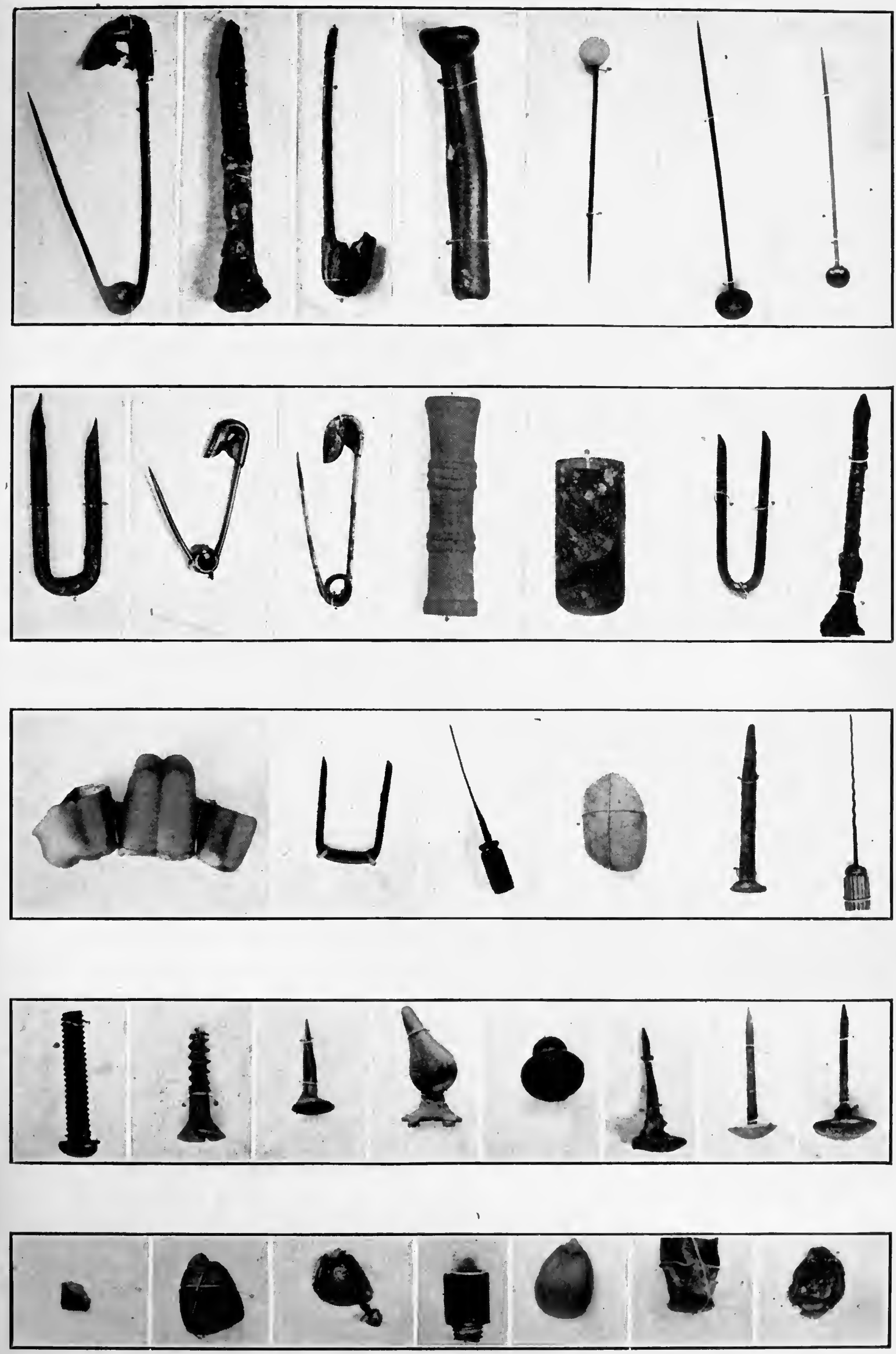


FIG. 523.—Foreign bodies removed from the bronchi bloodlessly by bronchoscopy through the mouth. (A few specimens from the author's collection of 753 foreign bodies.)

bronchoscopy in children. The duration should not be over twenty minutes in a child under one year of age, thirty minutes under five

Fig. 524.—Case No. Fbdy. 619. Radiograph showing safety pin very low in left lung of a girl aged fifteen years.

years of age. Bronchoscopies of this duration can be repeated once a week if necessary for a year without any harm to the patient if no

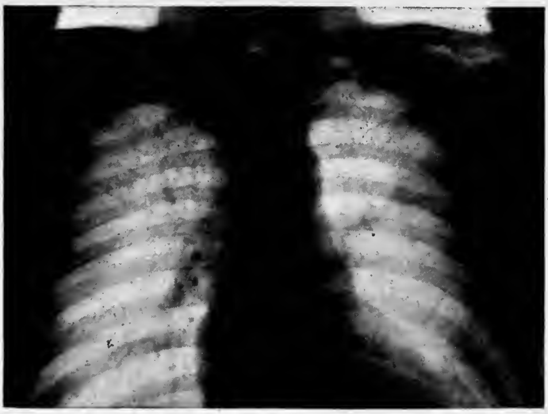


Fig. 525.—Case No. Fbdy. 409. Radiograph showing large fence staple in left bronchus of a man aged forty-three years. Present two years.

anesthetic be used, and, of course, if the utmost gentleness of manipulation be observed. The structures are tender and vital and anything like heavy-handed manipulation may be fatal. Overdistention of a bronchus by the use of too large a tube, or the tearing of the bronchial

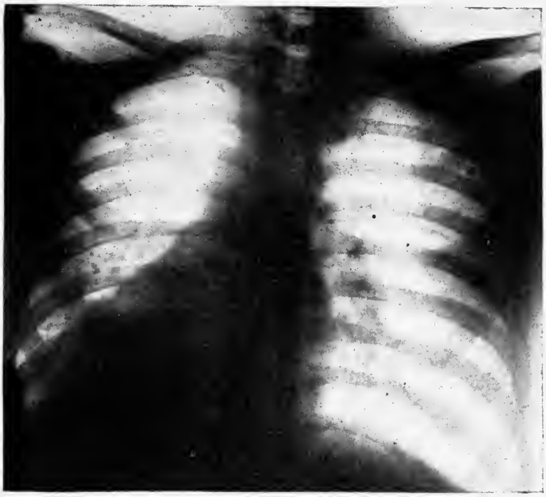


Fig. 526.—Case No. Fbdy. 440. Lead alloy collar button in left lung of a boy aged fourteen years. Probable sojourn about ten years. Note extensive pathologic change in left lower lobe. Compensatory emphysema of right chest.

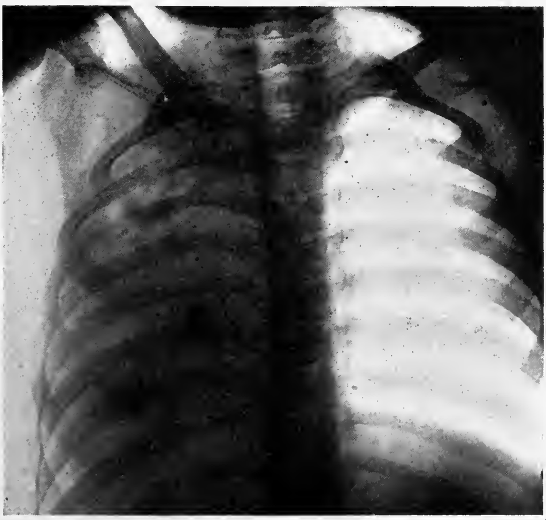


Fig. 527.—Case No. Fbdy. 572. Cap off brass bedstead in the right bronchus of a boy aged nine years. Probable sojourn about two years. Note dense pathologic shadow in right chest and compensatory emphysema in left.

wall in disentangling a foreign body may result in death within a few minutes from hemorrhage, in a few hours from mediastinal emphysema or in a few days from septic mediastinitis.

Tracheotomic Bronchoscopy.—In the early days of the development of the work it was considered necessary in many cases to do a tracheotomy for the insertion of a bronchoscopic tube. Development of an improved technic and improved armamentarium have rendered the tracheotomic route obsolete. There is absolutely no advantage whatever in passing the bronchoscope through a wound in the neck as compared with passing it through the mouth. If anything the peroral route is much more favorable. Of course, tracheotomy may be required for dyspnea and if so should be done, but in such a case the subsequent bronchoscopy should be done through the mouth and not through the tracheotomic wound. Of the last 300 cases of foreign body in the bronchi in the author's clinic the 294 foreign bodies that have been removed have been taken out through the mouth.

Fluoroscopic Bronchoscopy.—Fluoroscopic bronchoscopy is associated with a very much higher mortality than ocularly guided bronchoscopy as the following statistics of fluoroscopic bronchoscopies for foreign bodies by various operators will show:

Foreign body removed in 8 (66.7 per cent.).
Foreign bodies not removed 4 (33.3 per cent.).
Number of cases fatal within a week 5 (41.6 per cent.).
Of fatal cases foreign body removed in 3 (60 per cent.).
Of fatal cases foreign body not removed in 2 (40 per cent.).

From the foregoing it is clear that fluoroscopic bronchoscopy because of its high mortality and its low percentage of successes, has nothing to justify its use in any bronchially lodged foreign body case until after regular ocularly guided, endoscopic bronchoscopy has failed. The only cases in which its use is justifiable are those in which a small foreign body has gone far out to the periphery because of its small size or in those in which a large foreign body has worked its way out to the periphery by pathologic processes. In such cases the bronchoscopist should work by sight through the tube while the fluoroscopist tells him whether he should search farther to the right or farther to the left, anteriorly, or posteriorly as the case may be.

ESOPHAGOSCOPY.

Introduction of the Esophagoscope.—The patient should be in the position already described (see Fig. 507). It may be well here to emphasize again the fact that the patient's head must be high during the first stage of introduction.

For safety the esophagoscope must be passed by sight. The essentials of the author's method are as follows:

1. The correct "high-low" position-sequence of the patient.
2. A knowledge of the endoscopic anatomy in the living.
3. A clear conception of the direction and changes of direction of the esophageal axis as herein given.
4. A good general sense of direction that enables the endoscopist to point his esophagoscope in the general direction of the axis of the esophagus.

5. A clear mental image of the esophagus and its direction in relation to the esophagoscope.

With these qualifications the endoscopist has only to follow the landmarks to be able quickly to pass the esophagoscope on any human being whose mouth can be opened. The introduction may be divided into four stages.

1. Entering the right pyriform sinus.
2. Passing the cricopharyngeus.
3. Passing through the thoracic esophagus.
4. Passing the hiatus.

STAGE 1. Entering the pyriform sinus is readily understood by looking at the schema, Fig. 528. The aspirating tube being attached and the esophagoscope properly illuminated, the collar of the esophagoscope is held lightly between the thumb and fingers of the right hand while the left hand rests on the patient's upper jaw, the second and third fingers being inside of the alveolus, the thumb and index fingers supporting the tube, in much the same way as a billiard cue is handled. In order that the proximal end of the tube-mouth shall be kept very high

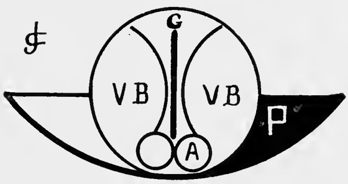


FIG. 528.—Schema for finding the pyriform sinus in the author's method of esophagoscopy. The large circle represents the cricoid cartilage. *G*, glottic chink, spasmodically closed. *VB*, ventricular band. *A*, right arytenoid eminence. *P*, right pyriform sinus, through which the tube is passed in the recumbent posture. The pyriform sinuses are the normal food passages.

the operator is standing erect with his eye at the proximal tube-mouth while he seeks the right pyriform sinus (Fig. 528). The landmark is the right arytenoid eminence. Great care must be taken to identify this arytenoid eminence. Great care must also be taken to avoid hooking the tube-mouth over this eminence, which accident would result in the prevention of further insertion and if force be used the arytenoid motility might be seriously impaired. Having found the right arytenoid the tube glides in readily for 2 or 3 cm. when it comes to a full stop and the lumen disappears. This is the spasmodically closed cricopharyngeal constriction. During stage 1 or any of the stages the fingers are not inserted in the mouth, except as far as necessary for the hooking of the phalanges over the alveolus in order to get anchorage for the tube, as shown in Fig. 529.

STAGE 2.—Passing the cricopharyngeus is, with the beginner, the most difficult part of esophagoscopy, especially if the patient is unanesthetized. Local anesthesia does not help. The relaxation of deep anesthesia does help very greatly but it does not seem justifiable to use an anesthetic for this purpose alone. When the solid firm resistance of the cricopharyngeal fold is felt, force must not be used, only a steady firm pressure should be made on the esophagoscope while a strongly anterior (lifting in the recumbent position) movement is imparted to the distal end of the esophagoscope by the thumb of the left hand, support of which is afforded by the second, third and fourth fingers inside the alveolus. During this process it is necessary to keep the tube very high. There is a great temptation to lower the proximal end and it requires firm determination on the part of the esophagoscopist to resist this tendency. At the same time the lifting motion is imparted with the thumb, the distal end of the esophagoscope should be guided slightly toward the middle line of the body as the esophago-

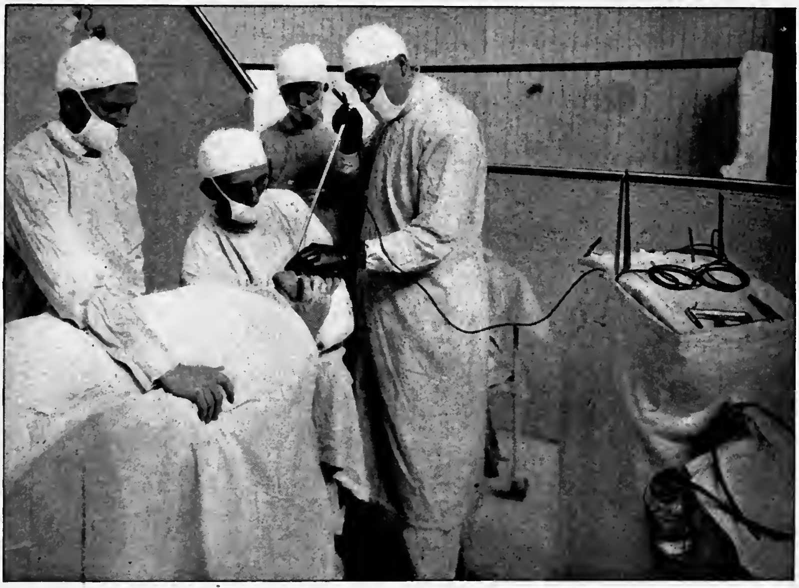


Fig. 529.—Esophagoscopy by the author's high-low method. First stage. Finding the right pyriform sinus. In this and the second stage the patient's vertex is about 15 cm. above the level of the table and in full extension.

scope is *lifted over* (patient recumbent) the fold on the posterior pharyngo-esophageal wall. Alternate pressing and releasing will not accomplish the result. As it is with depressing the rebellious tongue the pressure should be continuous, not intermittent; firm though not forcible. The lumen should be watched for anteriorly, and if it does not quickly appear the patient should be told to take a deep breath. A little patience here will always succeed. It is very essential that the handle be upward toward the ceiling in order to be certain that the lip of the esophagoscope is anterior. The manner in which this favors riding up over the obstruction of the cricopharyngeal fold will be understood by study of Fig. 530. Perforation is most apt to occur at the weak point in the esophageal wall between the oblique and orbicular fibers of the inferior constrictor. This is the same weakly supported point through which the esophageal wall herniates in the genesis of a diverticulum. After passing the cricopharyngeal fold it is noted that the cervical esophagus presents almost no resistance to the tube.

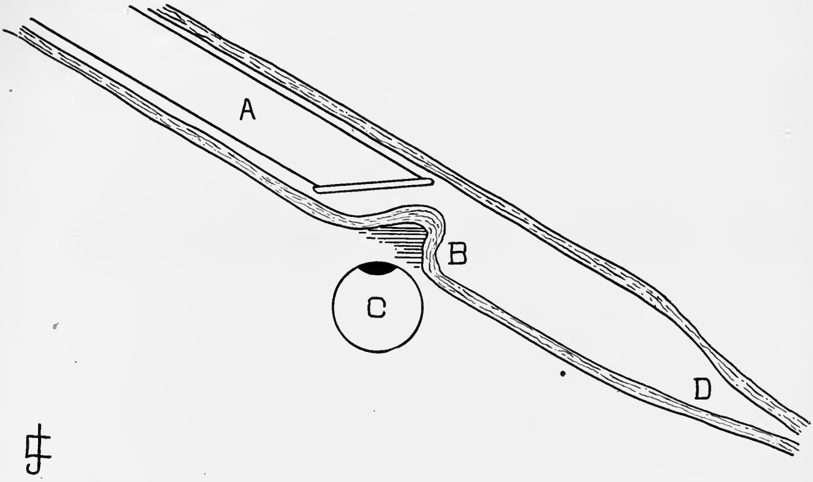


FIG. 530.—Schema showing how the tube-mouth (*A*) is lifted forward to raise it over the cricopharyngeal fold (*B*) as the latter relaxes, and the lumen opens up at the top of the field (*C*).

An alternative, less desirable method of executing stages 1 and 2, is to expose the pyriform sinus (Fig. 528) with the laryngoscope and then to pass through the latter a suitable esophagoscope, the laryngoscope being then removed, as in bronchoscopy. A small esophagoscope and a large laryngoscope are used.

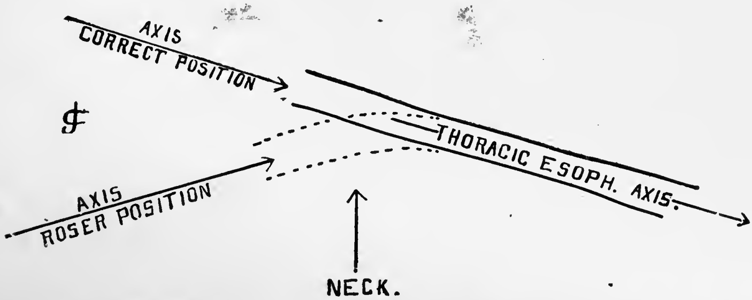


FIG. 531.—Schematic illustration of the author's "high-low" method of esophagoscopy. In the first and second stages the patient's head fully extended is held high so as to bring it in line with the thoracic esophagus, as shown above. The Roser position is shown by way of accentuation.

STAGE 3.—The esophagoscope usually glides easily through the thoracic esophagus. If it does not the patient's position is faulty or the esophagoscope is being fixed by friction on the upper teeth. The lumen of the esophagus must be followed very carefully and very accurately by watching it open up ahead, which it does as the result of negative pressure during inspiration. The levels of the aorta and left bronchus are readily recognized and in passing them the lumen of the esophagus seems to have more and more of a tendency to disappear anteriorly. This is the signal for lowering the head, which has until now been kept high. (Note the schematic illustrations, Figs. 531 and 533).

Stage 4.—Passing the hiatus is very easy after a little practice if the directions here given are followed. The direction of the lower esophagus is anteriorly and to the left. To follow this direction during esophagoscopy upon the recumbent patient the head is dropped as

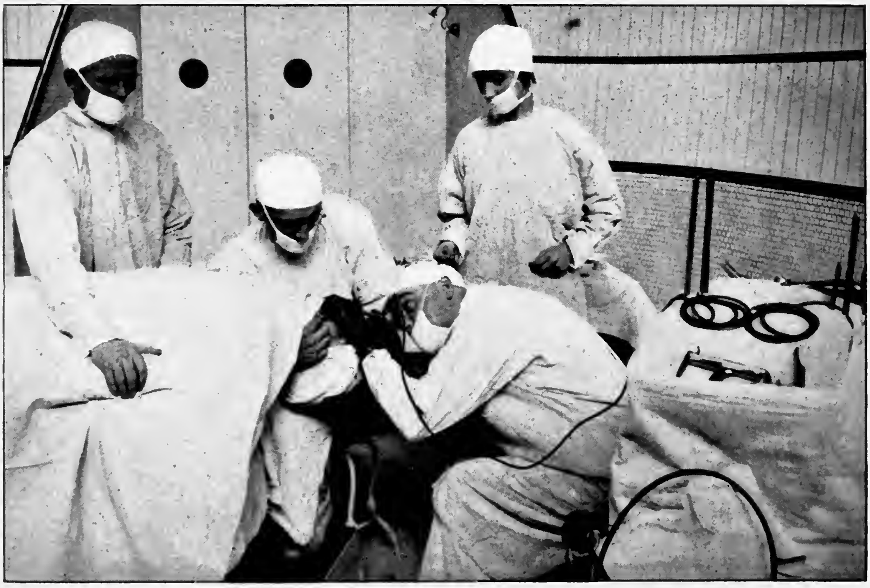


Fig. 532.—Esophagoscopy by the author's "high-low" method. Stage 4. Passing the hiatus. The patient's vertex is about 5 cm. below the top of the table.

shown in Figs. 532 and 533. When the head is dropped it must at the same time be moved horizontally to the right in order that the axis of the esophagoscope shall correspond to the axis of the lower third of the esophagus which deviates to the left so that the tube is pointing in the general direction of the anterior spine of the left ileum. This brings the tube-mouth quickly to the hiatal constriction which is a spasmodically closed, rosette- or slit-like orifice due to the contraction of the musculature of the diaphragm surrounding the esophagus at the hiatus esophageus. If the esophagus is normal the slit is very readily found and gentle but firm and continuous pressure is made until the spasmodic contraction yields and the esophagoscope glides quickly through the abdominal esophagus the length of which is approximately from 2 to 4 cm. in the adult. So quickly is this abdominal esophagus passed that early esophagoscopists mistook the hiatal opening for the cardia. It remained for the author to demonstrate the error. The author's high-low method of esophagoscopy can be more readily understood by the schemæ Figs. 531 and 533. It is in the perfecting of this method that esophagoscopy has developed from a slow laborious uncertain often impossible procedure into a very smooth satisfactory technic by which the esophagoscope can be passed in a few seconds in any patient that can open his mouth, provided the esophagus is pervious. The perfection of the method depends upon practice and upon the position of the patient which was developed by Dr. Boyce in conjunction with the author. No other position yields the same freedom

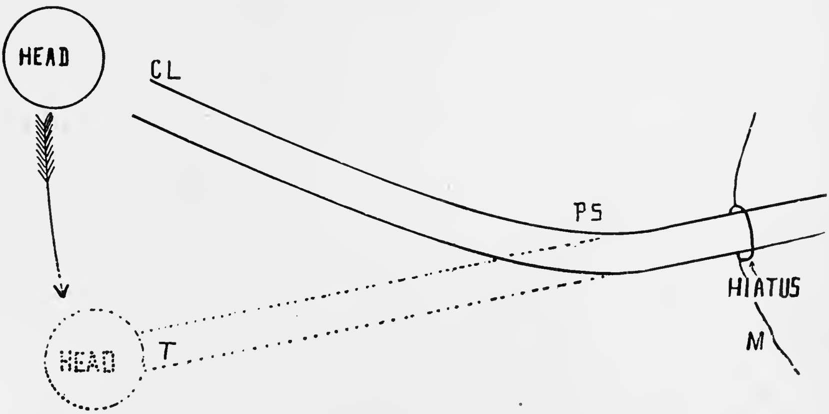


Fig. 533.—Schematic illustration of the author's "high-low" method of esophagoscopy, fourth stage. Passing the hiatus. The head is dropped from the position of the first and second stages, *CL*, to the position *T*, and at the same time the head and shoulders are moved to the right (without rotation) which gives the necessary direction for passing the hiatus.

of movement, a freedom that permits the patient to be promptly moved about in every direction in order that the operator may follow the lumen. Various mechanical methods of anchoring and fixing the patients have been advocated but all of them are a hindrance rather than a help so far as the introduction of the esophagoscope is concerned. Practice upon the cadaver under the tutelage of a skilful instructor is really necessary to learn the technic and the landmarks, and especially to learn how to avoid the mortality which is almost certain to follow uninstructed efforts at first upon the living. During esophagoscopy the aspirator which connects with the drainage tube in the wall of the esophagoscope keeps the field free from secretions which are constantly coming up from the stomach no matter how long the patient has been kept without food or water. These secretions, being much more watery than those of the bronchi, are readily aspirated.

Esophagoscopy for Foreign Bodies.—When the esophagoscope reveals the foreign body the tube is stopped at once and fixed against the upper teeth by means of the finger anchorage already referred to and illustrated in Figs. 514 and 532. This retains the esophagoscope in relation to the foreign body. The anchorage being accomplished with the left hand the right is free to take the forceps which are applied in the direction which has been determined by the previous observation of the foreign body itself. In the case of a foreign body such as a coin or button the intruder is seized flatwise and withdrawn, care being taken to keep its plane in correspondence with the lateral plane of the patient's body. When, as is usually the case, the foreign body is too large to come through the esophagoscope, the intruder is held closely against the tip of the tube mouth while forceps, foreign body and esophagoscope

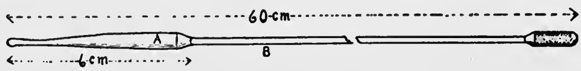


FIG. 534.—Filiform bougie for minute cicatricial strictures of the esophagus. The filiform silk woven end, *A*, is joined securely to a spring steel shaft, *B*, thus giving all the advantages in safety of a silk woven bougie at the tip with a stiff shank that enables the bougie to be carried down rigidly through the length of the esophagoscope. Twelve sizes are made. The total length of 60 cm. is only necessary in case of a very low stricture in an adult. For use in children, the bougie can be shortened by unscrewing. The great advantage of the steel shaft over any sort of stylet inserted into a hollow filiform is that the small diameter of the steel shank permits of more accurate ocular guidance.

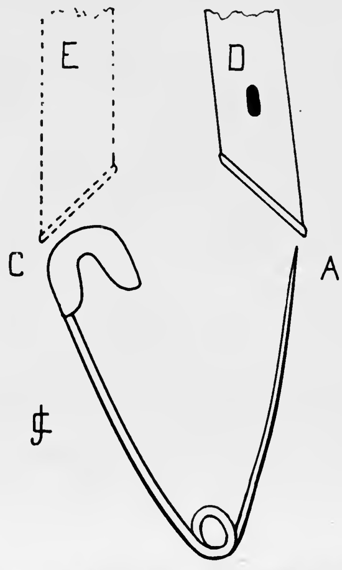


FIG. 535.—The problem of the safety-pin. Thirty-eight safety-pins have been endoscopically removed from the larynx, trachea, bronchi and esophagus, in the author's clinic, by this and other peroral endoscopic methods.

are all withdrawn together, their mutual relations being maintained by fixing the forceps against the proximal tube-mouth. If the foreign body has sharp points it must under no circumstances be pulled upon until the relation of these points to the mucosa is determined and the foreign body allowed to rotate into such a position that the esophageal wall will not be wounded. Traumatic esophagitis is almost invariably fatal.

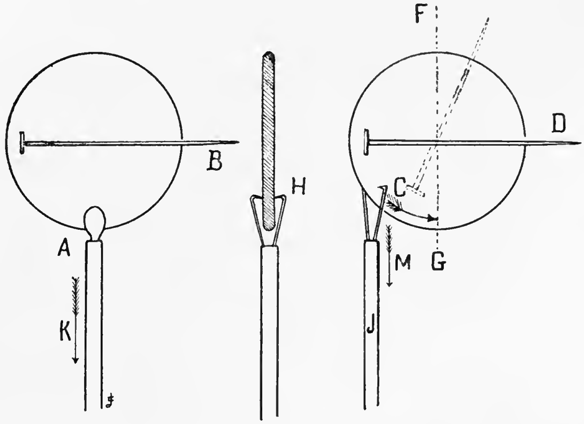


Fig. 536.—Solution of the mechanical problem of the button or other disk-like object with a sharp point. If withdrawn with a plain forceps applied as at *A*, the point, *B*, will rip open the esophageal wall. If grasped at *C*, the point, *D*, will rotate in the direction of *F* and will trail harmlessly behind. To permit rotation, the author's rotation forceps are used as in cross-section at *H*.

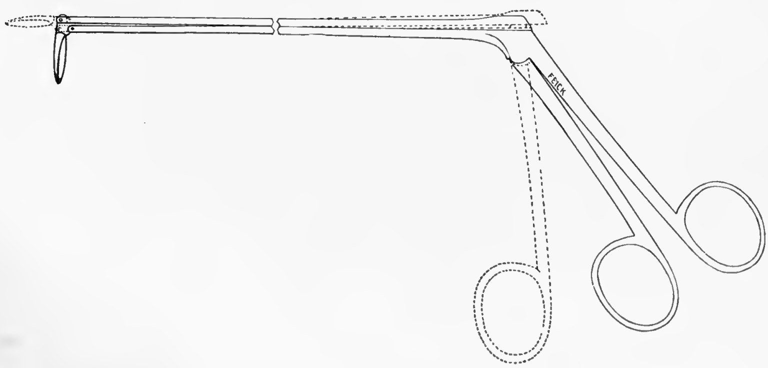


Fig. 537.—Mechanical spoon for short esophagoscope. A longer model is made for the esophagoscope.

Safety-pins may be closed by the method illustrated in Fig. 519, or they may be carefully passed down into the stomach, turned and removed. Still another method is shown in Fig. 535. The execution of any of these requires a great deal of preliminary practice with an esophagoscope inserted in a piece of rubber tubing in which a safety-

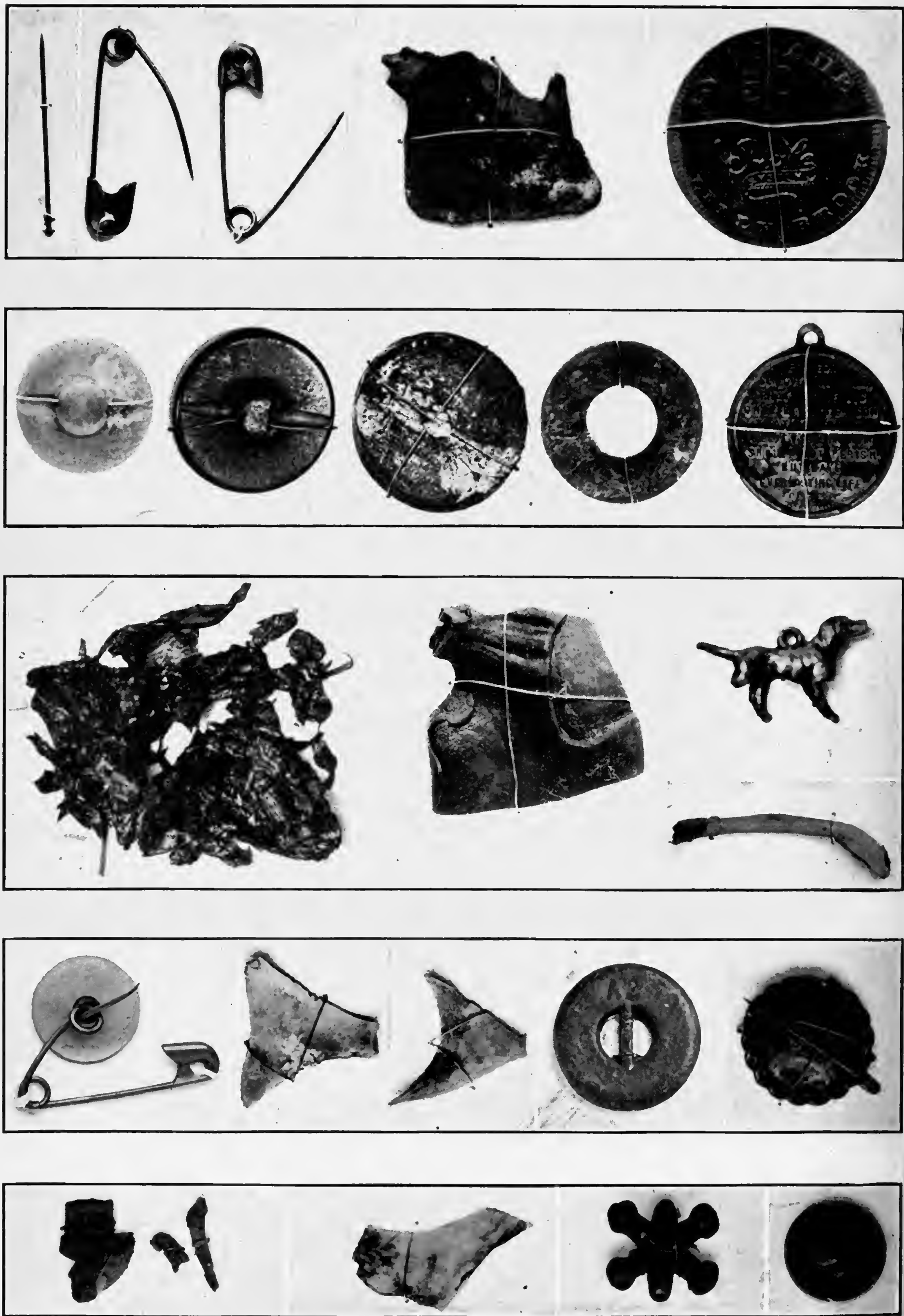


Fig. 538.—Foreign bodies removed from the esophagus bloodlessly by esophagoscopy through the mouth.

pin has been fixed in a position to simulate as nearly as possible a lodgment in the esophagus.

Buttons which have a sharp point are removed quickly and safely by the method illustrated in Fig. 536. Meat and other soft substances may be removed readily with a mechanical spoon, Fig. 537. The author's forceps are very convenient for reaching below the crico-pharyngeus into the region in which foreign bodies most often lodge in the esophagus.

Esophagoscopy for Disease.—Cicatricial stricture of the esophagus is very safely treated by means of the filiform bougies, Fig. 534, passed through the esophagoscope by sight. The usual method is to dilate the esophagus with increasing sizes at intervals of about one week, no anesthetic, general or local, being used. The method is vastly safer than any form of divulsion or of pulling through various dilators with threads. All procedures being under the guidance of the eye no stretching is done in the case of ulceration which is a very frequent attendant owing to stagnation of food in the esophagus above the stricture. Such cases are treated by the local application of silver nitrate or argyrol solutions and the internal administration of bismuth subnitrate dry on the tongue. As soon as the ulceration has healed the dilatation is proceeded with, the result being a cure in all cases in which there is not a total permanent cicatricial atresia.

Esophagoscopy for Hiatal Esophagismus (So-called "Cardiospasm.")—This condition is very readily recognized by the enormous dilatation of the esophagus, usually filled with stale food. The mucosa is coated with a white pasty adherent material which is very much in contrast with the pale shining pink mucosa of the normal esophagus. When the level of the hiatus is reached a broad floor is found to exist in the dilatation and in this floor the hiatus must be searched for. It will be tightly, spasmodically closed when found, but gentle pressure continued without intermission will cause it to yield and the esophagoscope will readily glide into the stomach. Esophagoscopy with a large-sized esophagoscope is itself a very efficient form of treatment. If it fail a mechanical dilator can be very readily used through the esophagoscope with excellent results and with perfect safety to the patient.

Esophagoscopy in Malignant Disease of the Esophagus.—Esophagoscopy affords the only means of making a very early diagnosis of esophageal cancer. If every patient who has the slightest symptom referable to the swallowing function were esophagoscoped esophageal cancer could be discovered very early and the diagnosis could be absolutely determined by the taking of a specimen with the forceps shown at *E*, Fig. 506. The rapid development of thoracic surgery renders it hopeful that the early diagnosis will enable the patient to obtain cure by external operation. No endoesophageal operation seems justifiable. Radium can be applied through the esophagoscope and has been quite efficient in retarding the progress of lesions not too far advanced. Large lesions are probably irritated. The malignantly stenosed lumen can be intubated for palliation by the esophagoscopic placement of a silk-woven Charters-Symonds tube.

BRONCHOSCOPIC AND ESOPHAGOSCOPIC VIEWS SHOWING THE PATHOLOGIC CHANGES FOLLOWING THE PRESENCE OF FOREIGN BODIES IN THE BRONCHI AND ESOPHAGUS.[1]

PLATE XIII.

Fig. 1.—Case Fbdy. 616B. Child, aged seven years. Steel shawl-pin with head downward to left in left upper-lobe bronchus. Point lying in contact with median wall of left main bronchus. Peroral bronchoscopic removal. Cure.

Fig. 2.—Case 269 P. E. Child, aged twelve years. Steel shawl-pin with head in left upper-lobe bronchus; point imbedded in median wall of left main bronchus. Endoscopic view two days after aspiration of pin. Peroral bronchoscopic removal. Cure.

Fig. 3.—Case Fbdy. 394B. Infant, aged eighteen months. Steel shawl-pin with head in left upper-lobe bronchus; point imbedded in median wall of left main bronchus. Pin probably *in situ* thirty-five days. Inflammatory state obliterating image of bronchial rings due to two previous rough bronchoscopies by an operator who was unable to see the pin. The grayish patch is exudate from improper instrumentation. Ordinarily reaction is only local around the buried point, as in Fig. 2. That the baby survived the two previous rough, prolonged bronchoscopies is remarkable. Usually such work is fatal to infants. I have never seen such a reaction from either a metallic foreign body or a carefully done bronchoscopy. Peroral bronchoscopic removal. Cure.

Fig. 4.—Case Fbdy. 577B. Girl, aged seven years. Steel shawl-pin with head in left upper-lobe bronchus; point imbedded in median wall of left main bronchus, the pin being transfixed across the lumen of the bronchus. Observed fifteen months after aspiration of pin, which is thickened and roughened by corrosion. Inflammatory state less than that of trauma from rough bronchoscopy in case shown in Fig. 3. This illustrates the surprisingly little and the remarkably limited inflammation set up by a metallic foreign body in the bronchi. It is only in the immediate neighborhood that the rings are obliterated by the inflammation, which, moreover, is essentially chronic. Peroral bronchoscopic removal. Cure.

Note.—Figs. 1, 2, and 4 afford a noteworthy opportunity for comparison of the effect of a foreign body of precisely the same character (steel pins with glass heads) in about the same location, but of various durations of sojourn.

Fig. 5.—Case Fbdy. 565. Girl, aged eight years. Steel shawl-pin with head in left main bronchus, the point in tracheal wall above orifice of right bronchus. A tiny stream of blood is seen to be carried by the cilia toward the posterior wall of the trachea. (See also Fig. 10.) Peroral bronchoscopic removal. Cure.

Fig. 6.—Case Fbdy. 625. Man, aged twenty-one years. Dental root-canal-reamer (tool steel with brass handle) in middle-lobe bronchus, the point having entered slightly into the mucosa. Faint areola around point of entrance. (Compare Fig. 11, in which a similar foreign body had been in a bronchus for three months.) Peroral bronchoscopic removal. Cure.

Fig. 7.—Case Fbdy. 569. Woman, aged sixty-three years. Steel shawl-pin was aspirated five years previously, and probably entered a branch of the middle-lobe bronchus. The yellow patch on the mound-like swelling represents a mass of pus and exudate.

Fig. 8.—Same case as in Fig. 7. The pus and exudate have been wiped away, revealing the end of the much-corroded pin occupying the strictured orifice of an abscess cavity. This appearance of a foreign-body abscess cavity is not unusual but the mound-like protrusion into the lumen of the bronchus is rare.

Fig. 9.—Same case as in Figs. 7 and 8. Interior of abscess cavity. The orifice was dilated and the pin was removed, a caisson-bronchoscope has been inserted and the cavity ballooned for examination of its interior. The nature of the band stretching across from wall to wall was not determined. It might have been vascular, bronchial or cicatricial tissue. Pus was very foul. All expectoration ceased after a few weeks and the patient is still well at end of two years.

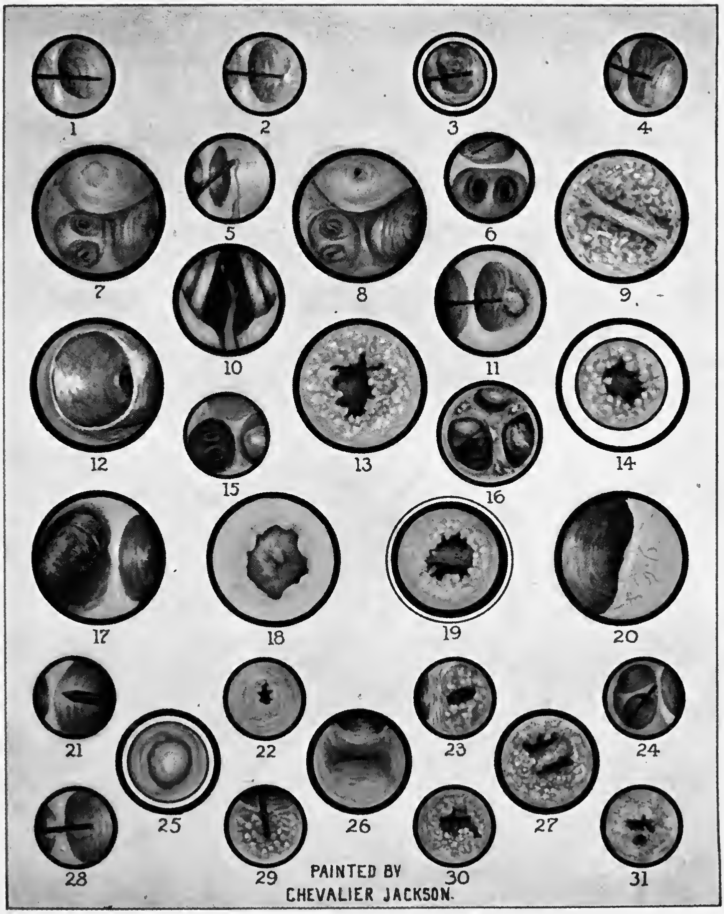
Note.—Comparisons of Figs. 1, 2, 4, 7, 8 and 9 are interesting as they show the pathologic changes of similar foreign bodies (steel pins with glass heads), present for various periods from two days to five years.

Fig. 10.—Same case as in Fig. 5. Tiny stream of blood is seen to be carried by the cilia up the posterior wall of the trachea and out the "pitcher mouth" between the arytenoids. This original observation of the author has been observed in previous and subsequent foreign-body cases. Occasionally it is seen in tuberculous cases. At intervals the cough removed the streak of blood; but it was soon replaced in cases in which the bleeding continued in sufficient and not too great amount. It was not noticeable in copious hemorrhages.

Fig. 11.—Case Fbdy. 552. Dental root-canal-reamer (tool steel with brass handle) in left upper-lobe bronchus for three months. The point has entered the wall of the main bronchus, the point of entrance being surrounded by an inflammatory areola. A small

[1] Mütter Lecture 1917, in Surg., Gynec., and Obst., March, 1919.

PLATE XIII


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
PAINTED BY
CHEVALIER JACKSON.

patch of exudate is adherent. The local and mild character of the inflammation is important. Compare Fig. 6, which shows the endoscopic appearance in a case of only two days' sojourn of a similar instrument.

FIG. 12.—Case 230 P. E. Man, aged seventy-six years. Nickel-plated brass atomizer tip in right stem bronchus ten days. Inflammatory reaction localized, probably because the foreign body is not of very irritating character and owing to the hole in the distal end, it does not obstruct drainage. Nickel-plating tarnished but not corroded. Peroral bronchoscopic removal. Cure.

FIG. 13.—Case Fbdy. 611. Man, aged fifty-eight years. Nickel-plated brass atomizer tip in right stem bronchus one and one-half years. The size, shape and position of this foreign body are precisely the same as in the preceding case. (See Fig. 12, above.) The granulation tissue that obstructs the view into the interior of the atomizer tip has developed as the result of a one and one-half years' sojourn. The granulations surmount a firm, fibrous stricture, which required bronchoscopic dilatation for the removal of the foreign body. Pus very foul. Perichondritis present. Nickelling entirely gone, brass much corroded. Peroral bronchoscopic removal. Cure.

NOTE.—The localized character of the inflammatory processes in the cases illustrated in Figs. 12 and 13, is noteworthy and is probably due to the relatively unirritating character of the foreign body and to its form, which because of the opening at both ends did not greatly obstruct drainage.

FIG. 14.—Case Fbdy. 572. Boy, aged nine years. Brass cap from bedstead in right main bronchus one year and nine months. The general shape and position of the foreign body are similar to Fig. 12; but there is no hole in the distal end of the cap. The obstruction to drainage had caused much more extensive pathology in the right lung (shown by roentgenography and physical signs) as compared to the two preceding cases. Endoscopically the bronchi of the left lung were normal, and this was corroborated by the ray and the physical signs, both the two last indicating compensatory emphysema. The illustration shows a proximal fibrous stricture covered with granulations. The pus was copious and very foul. Brass much corroded. (See radiograph, Fig. 22.) Peroral bronchoscopic removal. Cure.

FIG. 15.—Case Fbdy. 439b. Boy, aged six years. Peanut kernel projecting from the orifice of the right upper-lobe bronchus, two days after the kernel was inhaled. Intense diffuse bronchitis, which is particularly noteworthy in comparison with the relatively mild and markedly localized inflammation resulting from the presence of foreign bodies other than vegetable substances and especially in comparison with metallic bodies, particularly steel. Peroral bronchoscopic removal. Cure.

FIG. 16.—Case Fbdy. 584. Child, aged five years. Peanut kernels in middle-lobe bronchus and an anterior branch of the inferior-lobe bronchus, four weeks after the accident. Diffuse bronchitis, patches of exudate. The pus which was copious has been sponged away. The trachea and the bronchi of the other lung were also inflamed. A younger child would probably have succumbed in less time. Peroral bronchoscopic removal. Cure.

FIG. 17.—Case 369 P. E. Man, aged twenty-three years. Bullet, probably chiefly lead, in orifice of left bronchus. Accidentally inhaled a few days previously. Localized bronchitis. Lead not corroded. Peroral bronchoscopic removal. Cure.

FIG. 18.—Case Fbdy. 574. Amalgam tooth filling, probably composed of silver, tin and mercury; in left stem bronchus two weeks. Proximal annular edema, possibly due in part to tight impaction of the foreign body. Localized bronchitis. Bronchi of the upper lobe and of the other lung were normal. Peroral bronchoscopic dilatation of annular edema; removal of foreign body. Cure.

FIG. 19.—Case Fbdy. 440. Boy, aged fourteen years. Lead alloy collar button in left inferior-lobe bronchus eleven years. Proximal, firm, fibrous stricture, covered with granulations. Bronchiectatic cavity, below, lined with granulations, and filled with very foul pus. The button was somewhat corroded. Stricture dilated and foreign body removed by peroral bronchoscopy. Cure.

FIG. 20.—Case 243 P. E. Youth of eighteen years. Lead alloy collar button in right lung for ten years. Cicatricial web occluding half of bronchus. At bottom of dilated cavity is the lumen of a firm fibrous stricture. The foreign body was found immediately below this stricture after dilatation. The bronchiectatic cavity below was filled with foul pus. It seems probable that originally the collar button had remained for a long time at the location of the web. Peroral bronchoscopic removal of foreign body. Cure.

NOTE.—Figs. 17, 19 and 20 afford opportunity for comparison of the effect of short and prolonged sojourn of lead alloys in the bronchi.

FIG. 21.—Case 225 P. E. Boy, aged five years. Steel nail in right main bronchus one week. Superficial mild bronchitis. Nail coated thinly with film of corrosion. Peroral bronchoscopic removal. Cure.

FIG. 22.—Case Fbdy. 410. Boy, aged eleven years. Steel nail in right stem bronchus nine and one-half years. Chronic purulent bronchitis over entire right lung. Firm fibrous stricture of very small lumen. Granulations and very foul pus filling cavity below stricture. Nail corroded to a cinder-like mass that pulled apart on traction. Peroral bronchoscopic dilatation of stricture and piecemeal removal of foreign body. Cure.

Fig. 23.—Case Fbdy. 408. Steel nail in right main bronchus about three years. Much corroded nail clasped tightly in a bed of fibrous tissue and granulations. Pus very foul. Peroral bronchoscopic removal of nail. Apparent recovery, followed two months later by death from purulent process in lower thorax or upper abdomen. Post-mortem unobtainable.

Fig. 24.—Case Fbdy. 621. Girl, aged four years. Steel nail in left inferior-lobe bronchus one month. Bronchitis all over right side due to violent bronchoscopy before admission. Peroral bronchoscopic removal of nail. Cure.

Note.—Figs. 21, 22, 23 and 24 afford opportunity to contrast the effects of steel nail present in the bronchi for periods varying from seven days to nine and one-half years.

Fig. 25.—Case Fbdy. 624. Girl, aged four years. Pebble in right main bronchus three days. Proximal annular edema, probably from pressure of tighly impacted smooth, round, closely-fitting body. Localized bronchitis. In a previously reported case of a pebble the conditions were precisely the same. Peroral bronchoscopic extraction. Cure.

Fig. 26.—Case 266, P. E. Woman, aged twenty-three years. Brass tag-fastener in right lung seven years. Chronic bronchitis. Firm, fibrous stricture of stem bronchus, with slit-like lumen, below orifice of middle-lobe bronchus. Very foul pus was coughed through the stricture. A large cavity below the stricture was revealed after dilatation of the stricture. The foreign body was located at the top of the cavity, fixed in fibrous tissue. Foreign body (brass) corroded, but still strong after seven years' sojourn. Extraction. Cure.

Fig. 27.—Case 244 P. E. Woman, aged forty-eight years. Glass collar button in left lung for twenty-six years. On passing bronchoscope bronchus was found completely occluded by fibrous tissue. This was excised with biting forceps used through the bronchoscope, until a cavity was reached. Across the neck of the cavity, the collar button was found fixed in fibrous and granulation tissue, as here shown. The cavity contained very foul pus. The collar button was removed by peroral bronchoscopy and patient made a perfect recovery.

Fig. 28.—Case 233 P. E. Child, aged eleven years. Brass-headed steel tack in left upper-lobe bronchus four days. Slight congestion is present where the tack rests on the spur between the upper-lobe and stem bronchi. Slight areola of inflammation around the buried point of the tack on the inner wall of the main bronchus. Tack not visibly corroded but a black film was wiped away with gauze. Peroral bronchoscopic removal. Cure.

Fig. 29.—Case Fbdy. 382. Youth, aged eighteen years. Brass-headed steel tack in right bronchus. The head is buried in granulation tissue in the stem bronchus below the orifice of the middle-lobe bronchus; the point is buried in the anterior wall of the main bronchus. Pus foul. Localized bronchitis. The middle-lobe bronchus is relatively normal. Small amount of pus was found in uninvaded lung, probably drawn in shortly before bronchoscopy. Peroral bronchoscopic removal of tack. Cure.

Fig. 30.—Case Fbdy. 412. Boy, aged six years. Brass-headed steel tack in right bronchus two and one-half months. The head is buried in granulation tissue; the point has ulcerated outward through the bronchial wall; but this occurred so slowly that the mediastinum was not affected. Bronchus bronchiectatic below tack; dilatation filled with foul pus. Large area of "drowned lung." Peroral bronchoscopic removal. Cure.

Fig. 31.—Case 221 P. E. Woman, aged fifty-two years. Brass-headed steel tack in left lung two years. Granulations have been nipped away, revealing the point of the corroded steel shaft of the tack in an almost closed posterior branch of the inferior-lobe bronchus. The pus was very foul. Peroral bronchoscopic removal. Cure.

Note.—Figs. 28, 29, 30 and 31 afford an opportunity to contrast the pathologic changes present in 4 different cases, all of the same kind of a foreign body in the bronchi for periods varying from four days to two years. The head of these tacks was of umbrella-like shape, the obstruction by which would vary with changes of position.

PLATE XIV.

Fig. 1.—Case Fbdy. 411. Girl, aged seventeen months. Fishbones in right stem bronchus at orifice of upper-lobe bronchus "many days." Intense localized bronchitis. Peroral bronchoscopic removal. Cure.

Fig. 2.—Case 308 P. E. Infant, aged nine months. Fish-bone in right stem bronchus twenty-nine days. Bronchitis localized. Orifice of right upper-lobe bronchus normal. Peroral bronchoscopic removal. Cure.

Fig. 3.—Case Fbdy. 386. Woman, aged twenty-five years. Fishbones in branches of left inferior-lobe bronchus five weeks. Bronchitis limited to invaded branches and their orifices. Proximal portion of stem bronchus and the orifice of the upper-lobe bronchus are seen to be normal. Peroral bronchoscopic removal. Cure.

Note.—Figs. 1, 2, and 3 afford opportunities for noting the effect of fishbones in the bronchi for considerable periods.

Fig. 4.—Case Fbdy. 425. Infant, seventeen months. Walnut kernel in orifice of right upper-lobe bronchus three days. Diffuse tracheobronchitis. Note thickened

PLATE XIV


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
PAINTED BY
29 CHEVALIER JACKSON. 30
31

interorificial spurs. Severe diffuse bronchitis was present in left lung also. Peroral bronchoscopic removal. Cure.

Fig. 5.—Case Fbdy. 550. Boy, aged eleven years. Iron casting in right main bronchus three days. Localized bronchitis. Left bronchial orifice is normal. Peroral bronchoscopic removal. Cure.

Fig. 6.—Case Fbdy. 583. Child, aged two years. Half of the glass eye of a "teddy bear" in the right stem bronchus below orifice of upper-lobe bronchus four days. Localized bronchitis. The main bronchus above the stem bronchus was normal, as were also all the bronchi on the left side. Peroral bronchoscopic removal. Cure.

Fig. 7.—Case Fbdy. 399. Man, aged forty-four years. Galvanized steel staple (double-pointed) in a dorsal branch of the right inferior lobe bronchus fifteen days. Localized inflammation. Only the concavity of the rounded middle portion of the U-shaped staple is visible. The points are toward us, buried in the mucosa by coughing, and hidden by the annular inflammatory swelling. The orifice of the middle-lobe bronchus (above) and of the upper-lobe bronchus (to the right) are normal. The points of the staple were slowly and carefully freed, brought upward and turned down into the two anterior-branch orifices seen above the invaded bronchus to permit "version" of the staple for safe removal, which was followed by prompt and complete recovery. (See Journal American Medical Association, June 5, 1915, p. 1906.)

Fig. 8.—Case Fbdy. 409. Man, aged forty-three years. Large fence staple, galvanized steel, in left main bronchus two years. Localized bronchitis. Acute edema, due to efforts at bronchoscopic removal before admission, masks the chronic lesions somewhat. Localized bronchitis and perichondritis. The ring of reddish tissue hiding the upward projecting points is fibrous inflammatory tissue, much firmer than the acute edematous ring in Fig. 7. Vessels are visible. There were granulations deeper down below the fibrous ring, where the staple had been lying. The points are deeply embedded by prolonged coughing and ulceration. The staple was removed by version, the points being disembedded, brought upward and turned down into the right bronchus, whose orifice is shown to be right. The limitation of the inflammation after two years is remarkable. The carina is not thickened and the right bronchial orifice is normal. Peroral bronchoscopic removal. Cure.

Fig. 9.—Case Fbdy. 622. Postmortem bronchoscopic view of a rubber eraser lying in the orifice of the right main bronchus seven months. The carina is thickened. The thin, greenish, flocculent fluid filled both lungs and the trachea up to the larynx. The view represents conditions after the fluid had been removed sufficiently partially to expose the carina and the rubber. Both lungs were functionally destroyed in seven months.

Fig. 10.—Case Fbdy. 385. Chicken-bone lying loose at the orifice of a bronchiectatic cavity as seen after sponging. Usually foreign bodies of prolonged sojourn are fixed in inflammatory new formation. The bone had been in the lungs about a year. Peroral bronchoscopic removal. Cure.

Fig. 11.—Man, aged thirty-seven years. Perichondritis of the orifice of the middle-lobe bronchus. Unhealed cartilage is indicated by the granulations occupying the orifice of an anterior branch of the inferior-lobe bronchus, in the track of a bullet which passed through the chest thirteen months before. This shows the effect of trauma without the continued presence of the foreign body that inflicted it. (Perichondritis is often present in cases of prolonged sojourn such as 9, 14, 22, etc.). Rcovery after internal administration of small doses of potassium iodide and the use of thromboplastin.

Fig. 12.—Case Fbdy. 623. Man, aged thirty-nine years. Beef bone impacted in right main bronchial orifice as seen twenty-three days after aspiration. Acute localized bronchitis due to rough bronchoscopy before admission. The greenish patch of exudate is due to a wound made in a bronchoscopic attempt to remove the bone before admission. The left bronchial orifice is normal and the carina nearly so. Peroral bronchoscopic removal. Cure.

Fig. 13.—Case Fbdy. 310. Woman, aged thirty-nine years. Chicken bone transfixed in trachea. Contrary to the rule, this bone is in the lateral plane. The bone had been in the trachea six days, yet the reaction is limited to an areola around the points of fixation. This is in marked contrast to the cases of prolonged sojourn, such as shown in Figs. 10 and 14. Peroral bronchoscopic removal. Cure.

Fig. 14.—Case Fbdy. 608. Man, aged twenty years. The beef bone had been in the lung eleven years. It is shown beyond a firm fibrous stricture covered with granular inflammatory, partly epithelialized tissue. Perichondritis. The bone in its crosswise diameter is larger than the stricture but permitted continuous drainage, at both sides, and the lumen of the stricture was not small, which probably accounts for the survival of the patient for so many years in spite of the suppuration. There was a chronic bronchitis throughout right side. Peroral bronchoscopic removal. Cure.

Fig. 15.—Case Fbdy. 3676. Boy, aged fourteen years. Deciduous molar tooth completely obstructing the orifice of right upper-lobe bronchus, two months after accident. The inflammatory mass in which the tooth was embedded is thrown into prominence by strong lateral pressure with the lip of the bronchoscope. Distant bronchi and those of the other side were not inflamed. Peroral bronchoscopic extraction. Cure.

Fig. 16.—Case Fbdy. 578. Boy, aged three and one-half years. Ring of pearl shell (mollusk) in esophagus for a period of over one year. Localized chronic esophagitis, ulceration; swollen folds. Foreign body embedded in a pocket of inflammatory tissue, with granulations at the lateral edges. The shell had whitish incrustations at certain points, but whether or not they occurred during the sojourn in the esophagus could not be determined. Esophagoscopic extraction. Cure.

Fig. 17.—Case Fbdy. 431. Boy, aged twelve years. Cockle burr in larynx one day. Moderate acute laryngitis; not nearly so severe as one would anticipate from the prickly nature of the foreign body. Extraction. Cure.

Fig. 18.—Case Fbdy. 432. Girl, aged four years. Lead alloy image of a horse in the larynx more than one month. Larynx swollen almost shut. Granulations, ulceration. Tracheobronchitis was present from the accumulation of secretions due to glottic obstruction and loss of the aid of glottic movement in the bechic cycle. Lead alloy partly covered with a colored varnish, partly not. No apparent corrosion. Direct laryngoscopic removal. Cure.

Fig. 19.—Case Fbdy. 364. Boy, aged four years. Brass safety pin in larynx more than two months. Larynx swollen nearly shut. Glottic margins eroded. Tracheobronchitis was present from accumulation of secretions that could not be expelled, as in preceding case (Fig. 18). Brass pin blackened by corrosion. Removal. Cure.

Fig. 20.—Case Fbdy. 628. Boy, aged twelve years. Coin (silver half-dollar) in esophagus five days. Slight congestion of esophagus; no esophagitis. The silver surface is bright at the sides where it was clasped in the esophageal folds. The vertical central zone on all surfaces is black with a thick dull corrosion, probably sulphides. Esophagoscopic removal. Cure.

Fig. 21.—Case Fbdy. 426. Nursing infant, girl, aged six months. Gold "filled" cuff-button partly in trachea and partly in esophagus. (See Fig. 28). Button had been swallowed three months before and had evidently ulcerated through the party wall into trachea, the large part of the button being in the esophagus, the stem between the two parts occupying a fistula through the party wall. Granulations around the fistula. Tracheobronchitis probably from mother's milk leaking through fistula while taking breast. The metal was corroded in patches. Endoscopic removal. Cure.

Fig. 22.—Case Fbdy. 630. Girl, aged twelve years. Shoe-button (fiber composition with steel eyelet) in left stem bronchus seven months. Chronic bronchitis limited to left lower-lobe bronchus. Granulations form a bed for the button and obstruct drainage. Some degree of bronchiectasis was noticeable below the button. Fiber unchanged, steel eyelet corroded. Bronchoscopically removed. Cure.

Fig. 23.—Case Fbdy. 558. Boy, aged about two years. Cast-iron "jack" in esophagus about two months. Esophagitis, inflammatory infiltration, granulations. (Compare Fig. 30.) The cast-iron was not corroded in the slighest degree in its two months' sojourn.

Fig. 24.—Case Fbdy. 434. Woman, aged fifty-seven years. A U-shaped bit of tinned wire from an eggbeater in the esophagus for five weeks. The only inflammatory reaction is a small areola around the location where the two sharp, hook-shaped points have buried themselves in the mucosa. The wire was not corroded except on spots where the tinning was absent. Esophagoscopic removal. Cure.

Fig. 25.—Case Fbdy. 358. Girl, aged five years. Copper (or bronze) halfpenny (British) in esophagus twenty hours. No local reaction; not even congestion. (Compare Fig. 26). Coin not corroded. Esophagoscopic removal. Cure.

Fig. 26.—Case Fbdy. 559. Girl, aged four and one-half years. Copper (or bronze) halfpenny (British) in esophagus eight months. Granulation, fibrous narrowing, swollen folds. (Compare Fig. 25.) The penny was very much corroded. Esophagoscopic removal. Cure.

Fig. 27.—Case Fbdy. 354. Boy, aged two and one-half years. Gold locket in esophagus thirty-six hours. No inflammation or congestion. No corrosion. Esophagoscopic removal. Cure.

Fig. 28.—Same case as shown in Fig. 21. The large end of the cuff-button is here shown as seen in the esophagus, the stem disappearing in the anterior wall occupies a fistula leading into the trachea. There is a moderate esophagitis with swollen folds and rough granular mucosa. Peroral endoscopic removal. Cure.

Fig. 29.—Case Fbdy. 590. Girl, infant, aged nine months. Wool from a blanket in esophagus many days. No esophagitis. Mucosa not reddened. (Patient a nursling and very anemic.) Below the wool there was a mild esophagitis surrounding three other foreign bodies; namely, a fragment of a button, a cherry pit, and a mass of cotton-wool. All were extracted by esophagoscopy. Recovery.

Fig. 30.—Case 234 P. E. Infant, eleven months old. Cast-iron "jack" in esophagus two weeks. No esophagitis. Slight congestion. (Compare Fig. 23.) No corrosion of the cast-iron. Esophagoscopic extraction. Cure.

Fig. 31.—Case 93. Boy, aged three years. Probang bristles in esophagus seven days. Intense esophagitis due to use of probang before admission. To the right are seen two linear abrasions covered with exudate. Esophagoscopic removal. Cure.

SURGICAL DISEASES OF THE THYROID AND PARATHYROID GLANDS.

By NELSON M. PERCY, M.D.

GOITER.

In reviewing the literature on the subject of goiter, one is immediately impressed with the great number of articles which have been written within the past few years. Very often the literature is so contradictory, that if one were to balance the views of the many observers the result would be almost *nil.* This observation alone is sufficient to acquaint one with the fact that our scientific knowledge of goiter is yet very limited. For this reason it is the plan of the author to state only those facts which have been proved by well-known methods, or those theories which apparently corroborate the clinical findings in our cases of goiter.

The clinical history of goiter dates back nearly a century and a half when in 1786 Parry[1] described the condition known as exophthalmic goiter. The surgical history of goiter, however, was very meager until the last quarter of the nineteenth century, when Kocher attracted great attention by his practical demonstration in hundreds of cases, that thyroidectomy, if skilfully performed, was a comparatively safe operation and not as dangerous a procedure as the earlier surgeons had thought.

Moebius,[2] in 1886, added a very important element to the surgical treatment of exophthalmic goiter, when he demonstrated, quite conclusively, that in this disease there is an absorption of some toxic substance secreted by a diseased thyroid gland which enters the general circulation through the lymphatic system. There is no doubt but that the surgical work of Kocher in simple goiter, and the physiological and pathological explanation of Moebius in exophthalmic goiter, has much to do with establishing the surgical treatment of exophthalmic goiter.

In the year 1835 Graves,[3] in his course of lectures, which were published in 1843, described the disease now known as exophthalmic goiter so clearly that it became known as Graves's disease by all English-speaking physicians.

In 1840 von Basedow[4] described the same disease in Germany, from which source it derived the name of Basedow's disease.

[1] Quoted by Ochsner and Thompson, Thyroid and Parathyroid Glands, 1910.
[2] Schmidt's Jahrb. d. in. und aus. gesamt. Med., 1886.
[3] System of Clinical Medicine, Dublin, 1843.
[4] Casp. Wchnschr. f. d. ges. Heilk., 1840.

The condition known as myxedema was described by Gull in 1873. In 1882 Kocher established the fact that when the entire thyroid gland was removed, myxedema developed, hence his introduction of the term cachexia strumipriva. The most important historical data is that of Moebius, when, in 1886, he established the fact that exophthalmic goiter was due to some toxic substance in the circulation from a pathological activity of the thyroid gland. Moebius' theory is quite generally accepted today, and has been proved, from the surgical standpoint, by the cure of many patients suffering from exophthalmic goiter whenever the diseased portion of the thyroid gland had been removed.

The development of a safe and satisfactory surgical management of goiter belongs to our contemporary surgeons, much of which has come from the works of C. H. Mayo, Ochsner and Crile.

Etiology.—Goiter, in the various forms, is found in all countries, regardless of race, but is more prevalent in Europe, Asia and North and South America. In North America enlargement of the thyroid does not occur endemically to any appreciable extent, neither have any epidemics occurred such as have been reported in Europe.

In chronic types of goiter the drinking water probably plays an important role. Kocher found in the Canton of Berne, Switzerland, that there were what might be termed goiter fountains, because these waters almost invariably produced goiter in children who drank it. On the other hand, people who lived in the same district but received their water supply from elsewhere did not develop the disease. Wilms,[1] in a series of experiments upon dogs, monkeys, rats and guinea-pigs, found that enlargement of the thyroid followed regularly after ingestion of water from certain springs in regions where goiter was endemic. Goiter also developed in the animals when the residuum after filtration of such water was added to water from springs in other regions free from goiter. Bircher[2] also carried on similar experiments and caused struma in rats by causing them to drink water of the particular geographical sources that are known to cause it in human beings. His series embraced 120 animals, was carefully controlled and consisted of animals from various districts. Against the 120 successful attempts in producing goiter, there was not a single tumor found in the control animals. Balfour,[3] in his study of patients with goiter who have come to the Mayo Clinic, made a careful routine inquiry into the environment of the individuals, particularly with reference to the water supply during their entire lives, and found nothing suggestive of any relationship to water as an etiological factor in the production of this disease.

Modern evidence, however, seems clearly to show that certain agents ingested through the intermediary of water may cause the disease, and that there are certain districts in which endemic goiter is due to some water-borne agent. There are different theories as to the nature of this agent, one being that there is some substance in the drinking

[1] Deutsch. Ztschr. f. Chir., January, 1910.
[2] Ibid., 1911, Bd. cxii, Nos. 4–6.
[3] Mayo Clinic, 1914, vol. vi.

water, or in excess in the water, causing goiter, as in Europe, the geological formation of many of the affected districts contained vast masses of limestone. McLelland,[1] for example, found that 50 per cent. of persons living in certain limestone districts in India had goiter, while in only 1 per cent., or even 0.5 per cent., did it occur in non-limestone districts.

Kocher has maintained for some time that the prevalence of goiter depended upon the amount of organic matter in water rather than upon the water itself, the real exciting cause being a pathogenic organism or the toxin from such. The fact that by experimental work it was found that water which regularly produced goiter, failed to produce the disease after it had been boiled, would tend to substantiate the above theory.

McGarrison,[2] after extensive experiments believes, that the etiological factor in endemic goiter, is infection from the gastro-intestinal tract, although as yet he has not been able to isolate the specific toxic agent. Some of his conclusions are: Goiter is caused by an organism invading the body of man. All the evidence points to the intestine as the seat of infection. In nature it lives in the soil of infected localities. It is carried to man in the drinking water by contact with the soil or by other means yet unknown. The virus is given by persons suffering from goiter, in some way as yet undetermined, but most likely by means of the feces. He has been able to cause goiters to disappear entirely by the use of vaccines prepared from the normal bacteria inhabiting the intestinal canal. In this connection it is interesting to note that Sir Arbuthnot Lane[3] believes that all goiters are due to auto-intoxication from the intestinal canal, and reports cures in both simple and exophthalmic cases following short-circuit operation upon the colon.

In our own series of cases there have been a number of cases in which all the children in a family remained free from goiter until the family took up its abode on a new farm, when all of the younger children developed goiter, while those who were born after a subsequent change of location again remained free.

The observations of Bircher in Rapperswyl, Switzerland, are, however, most striking. More than 70 per cent. of all children born and raised in the village developed goiter while the original water-supply was in use, while of those born since the introduction of the new water-supply almost none have developed goiter. The original water supply was taken from one side of the valley where the land had been submerged in past ages, while the opposite side of the hill was composed of granite rock.

Classification of Goiter.—The reason so many classifications of goiter have been advanced is that there has not heretofore been found, between clinical symptoms and pathological findings, a definite and

[1] Quoted by Berry, British Med. Jour., April 14, 1906.
[2] Lancet, January 25, 1913.
[3] British Med. Jour., 1913, i, 1125.

constant relation that is satisfactory to a majority of workers. It was for this reason that MacCarty[1] recently made a most academic, and at the same time comprehensive study, of 3000 specimens, examined both grossly and microscopically, in the fresh state immediately after surgical removal. An attempt was made not to color the observations in any way by speculations nor by previous descriptions.

There are two main divisions of the types of goiter: the symmetrical or thyroid-shaped and the asymmetrical or nodular goiter. This very general classification has no special interest except in the study of the gland as a mechanical system of units.

In the symmetrical group are found, histologically, any one or a combination of the following conditions: (*a*) a simple dilatation, with colloid of the glands, which may be called the "hypertrophic colloid goiter;" an increase in the size of the cells lining each acinus, called the "hypertrophic parenchymatous goiter;" an increase in the number of cells in each acinus, in the "hypertrophic colloid parenchymatous goiter;" or a mixture of any or all of these types.

In the asymmetric or nodular type of goiter there are those that give evidences of general or systemic involvement and those that give signs and symptoms due only to the presence of the growth in the neck. The latter are most commonly called "simple" and the former "exophthalmic." Pathologically there are seen goiters with and goiters without hypertrophy or hyperplasia. The majority of goiters in the "simple" list do not show, microscopically, hypertrophy or hyperplasia. Conversely, the great majority—and possibly all—of the specimens removed from patients with symptoms of "exophthalmic" goiter show positive evidences of such changes. These, in substance, are the main constant findings generally recognized by most of the observers.

Plummer[2] after correlating the clinical findings in a large number of cases of goiter coming to operation, with the pathological findings of Wilson and MacCarty in the same cases, divides goiters according to their clinical and pathological relationship into four groups:

Group I. Non-hyperplastic atoxic.
Group II. Non-hyperplastic toxic.
Group III. Hyperplastic atoxic.
Group IV. Hyperplastic toxic.

Non-hyperplastic Atoxic Goiter.—Under this heading may be considered all so-called "simple" or "colloid" goiters associated with which there are no systemic symptoms that may be attributed to the enlarged thyroid gland. Grossly, these thyroids are large, lobulated, hard growths which usually cause pressure against the surrounding structures. Upon section, a thick mucilaginous substance or colloid is seen in easily visible distended acini. Various degenerations are often present, usually, however, being cystic or hemorrhagic changes. These degenerated areas are most often found in the center of the gland, leaving an outside layer of thyroid tissue well supplied with blood from

[1] Surg., Gynec. and Obst., April, 1913, p. 406.
[2] Am. Jour. Med. Sc., 1913.

the adjoining capsule. Microscopically, there are seen large dilated acini filled with eosin-staining colloid and lined with a single layer of cuboidal cells. In many instances these lining cells are flattened out to a marked degree, indicating pressure from overdistention.

FIG. 539.—Dilated acini filled with colloid in a case of simple goiter.

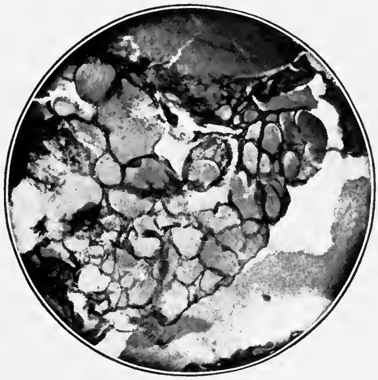


FIG. 540.—Degenerated colloid goiter in a case with toxic symptoms.

NON-HYPERPLASTIC TOXIC GOITERS.—In this group are found enlarged thyroid glands without evidences of hypertrophy or hyperplasia, but in which there have been symptoms apparently traceable to the gland, which symptoms are not identical with those found in cases of hyperthyroidism. In some instances this toxemia is due, in all probability, to the absorption of products from degenerated areas in the gland. In other cases there are found no microscopic processes

FIG. 541.—A lymph follicle in thyroid tissue.

FIG. 542.—Diffuse colloid adenoma in a case of simple goiter.

to account for the fact that the gland is secreting some substance which is not present in the normal gland. There is less definite clinical and pathological knowledge of this group of cases than of any of the other groups.

Hyperplastic Atoxic Goiters.—In only 0.8 per cent. of the cases showing no symptoms of hyperthyroidism are found microscopic areas of hyperplasia after operation. The fact that this class is so very small is the best evidence that there is a definite relationship in nearly all cases between clinical symptoms and pathological findings, and which fact thereby gave Plummer a basis for founding such a classification.

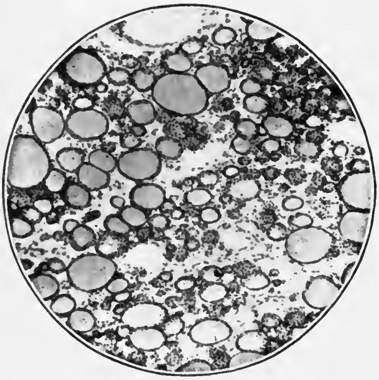


Fig. 543.—Fetal and colloid adenoma in a case of simple goiter.

Fig. 544.—Mixed adenoma in a case of simple goiter.

Hyperplastic Toxic Goiters.—It is in this group that cases of "hyperthyroidism" or "exophthalmic goiter" are classified. In most cases the typical findings can be made out in all portions of the gland, while in others it may be necessary to utilize serial sections of different portions of the gland to demonstrate hyperplasia, as very often a small piece removed for examination is not representative of the entire pathology of the organ removed. It would seem from this observation that a very small, possibly microscopic, area of hyperplasia in a gland may be the cause of constitutional symptoms.

Fig. 545.—Hypertrophy in a colloid adenoma.

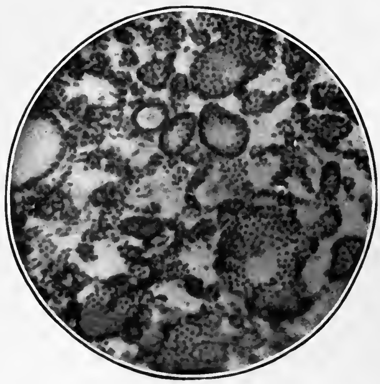


Fig. 546.—Secondary hyperplasia in an exophthalmic goiter.

There are several types of hyperplasia to be found in these goiters. The simplest type, hypertrophic parenchymatous goiter, consists of glands the lining cells of which have increased in size, but usually not in numbers. Colloid may be but usually is not present in the acini. In the gross this gland has the appearance of raw beef, is solid, symmetrical and usually not large.

Fig. 547.—Typical hypertrophy and hyperplasia in a case of exophthalmic goiter.

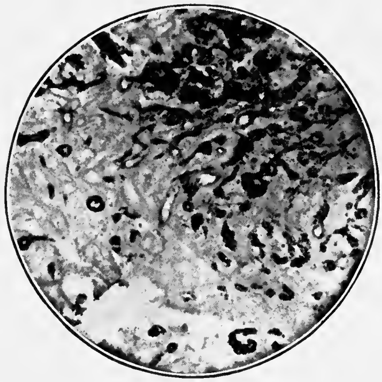


Fig. 548.—Fetal adenoma with marked fibrosis of interstitial tissue, case with mild symptoms of hyperthyroidism.

When the cells have markedly increased in number within each acinus, due to secondary hyperplasia, so as to give the appearance of a papilloma-like growth, it is called a hypertrophic colloid and parenchymatous goiter. These types of hyperplasia are usually found in

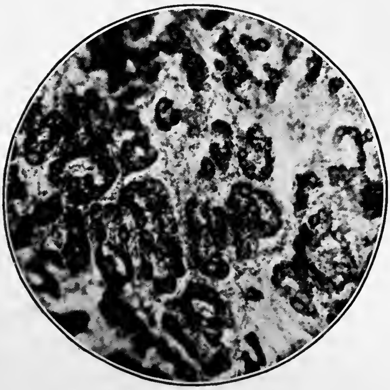


Fig. 549.—Carcinoma of thyroid gland.

Fig. 550.—Tertiary hyperplasia of an adenoma with beginning malignancy.

symmetrical goiters. Asymmetrical or nodular goiters owe their irregularity practically always to the presence of one or several adenomata of different shapes and sizes, and which are usually definitely encapsulated in fibrous tissue. These adenomata are the result of local glandular hyperplasia, *i. e.*, instead of an increase in size or number of cells in each acinus there is a great increase in the number of acini. Grossly, when there is no degeneration present, the adenoma has a solid, smooth appearance in which there can be seen very little if any visible colloid.

The acini are of the fetal type in practically every instance, though in some cases a comparatively small number of the fetal acini are found. The adenomata may vary in diameter from 1 mm. to several centimeters, and they may undergo any type of degeneration. One occasionally sees in one goiter all of the following: granular, fatty, fibrous, cystic, hemorrhagic, hyaline, necrotic and calcareous changes. Such goiters are very nodular and characteristic in appearance. Cystic degeneration is the form most commonly seen. These cysts usually contain cholesterin crystals such as are usually seen in cysts of long duration in any part of the body when accompanied by hemorrhage. In those portions of the goiter surrounding the adenomata may be found normal tissue undergoing pressure changes or any of the forms of hypertrophy or hyperplasia previously described.

Tertiary hyperplasia or carcinoma is rather rarely encountered either within adenomata or in the surrounding goiter substance.

NON-HYPERPLASTIC GOITER (SIMPLE GOITER).

Symptoms.—The symptoms of simple goiter are mechanical, that is, they are all secondary to pressure on the surrounding structures. These symptoms do not depend so much upon the size of the goiter as upon the shape and consistency and its location, especially in relation to the trachea. The most common symptom is dyspnea, which is usually due to direct pressure upon the trachea, causing the deviation or compression of the same, or less frequently it is produced secondarily by pressure on the bloodvessels, with consequent disturbance of the circulation. This occurs only from the pressure of very large goiters. Very moderate or very small goiters may produce marked deviation of the trachea, causing very distressing symptoms if a nodule happens to become wedged in between the trachea and esophagus. Dyspnea may be constant or paroxysmal and is increased upon exertion. In the beginning it is usually present only on exertion. In substernal and intrathoracic goiter there is liable to be considerable deformity of the trachea on account of their situation, with rather constant respiratory symptoms. When the lumen of the trachea is greatly compressed there may be present a whistling sound during inspiration and expiration, the so-called tracheal stridor. Occasionally a small goiter, spherical in character, involving the median lobe, may cause little or no discomfort when the patient is in the sitting or the erect position, but as soon as she lies upon her back, the goiter causes pressure upon the trachea, causing more or less marked dyspnea.

Occasionally in large bilateral goiter, and frequently in the intrathoracic form, there is an obstruction of the venous circulation, evidenced by an enlargement of the anterior external jugulars, and occasionally by cyanosis of the face, lips and tongue and by headache. A secondary dyspnea is usually present.

Dysphagia.—Actual dysphagia does occur but is extremely rare. Many patients, however, will complain of some feeling of pressure during deglutition.

Involvement of Nerves.—More or less pressure on one or both laryngeal nerves is quite common. Temporary hoarseness is quite frequent and is noticed on taking slight colds or from any excessive use of the voice. Constant pressure on either nerve may produce a paralysis of the nerve, with a consequent change of the voice. If the pressure on the nerve has been gradual the patient may not have noticed the change of voice tones. A sudden paralysis of one nerve will result in an immediate hoarseness, but this may gradually disappear by a swinging over of the healthy vocal cord to the paralyzed cord.

Matthews[1] in a careful examination of 1000 consecutive cases, found 17 patients with a paretic affection of both cords, 93 with an involvement of the right cord alone and 162 with involvement of the left vocal cord. Thus the frequency of involvement of the recurrent laryngeal nerves makes it important to determine the condition of the nerves when a surgical operation is contemplated. If it is found that one vocal cord is paralyzed the surgeon should use extreme care to avoid any manipulation that might cause any interference with the nerve on the opposite side. The sympathetic nerve is rarely affected in ordinary goiter. Plummer[2] has observed both paralysis and irritation of the sympathetic, but states that it is not always possible to determine whether the disturbances are due to mechanical or functional causes. The paralysis affects chiefly the oculopupillary fibers, while the irritation shows itself in the vasomotor and secretory nerves.

Pain.—Pain which can be attributed to simple goiter is extremely rare; when present it usually indicates some inflammatory process. Occasionally in suddenly increasing goiters due to a hemorrhage taking place in the gland, pain will be present, but disappears as soon as the increased tension has subsided.

Cough.—Cough is not an uncommon symptom. When present it is due to pressure upon the trachea. The patient usually locates the source of the cough as being in the larynx.

Diagnosis.—The diagnosis of goiter in itself usually is not a difficult matter, because of the definite location of the thyroid gland and its attachment to the trachea, causing it to move upward during the act of swallowing. The goiter, unless it be a very large one, occupies the normal position of the thyroid gland. This is practically always the case in diffuse goiter, which ordinarily retains the shape of the normal gland. Uniform enlargement of the entire gland, however, is not the rule. One lateral lobe and the isthmus are more frequently involved than both lateral, the right one being involved more often than the

[1] Jour. Am. Med. Assn., 1910, pp. 826–828. [2] Ibid., 1912.

left. When both lateral lobes are involved the right is usually larger than the left.

FIG. 551.—Goiter involving both lobes and larger on the right. Note that this goiter is a diffuse enlargement of the gland and that the normal shape of the gland is retained.

Nodular goiter, in contradistinction to the diffuse form, is liable to occupy a different position, and more frequently makes pressure upon the surrounding structures, depending greatly upon the size, shape

FIG. 552.—Diffuse goiter which is well restrained behind neck muscles.

and location of the tumor. Occasionally one meets with a nodular goiter in which the growth involves only the lower pole of one lobe, this extending downward beneath the sternum, so that no enlargement of the thyroid is noticed. The position of a goiter is determined by inspection, palpation, percussion and auscultation. Occasionally the

Fig. 553.—Substernal goiter. The left lobe is chiefly involved and lies behind the manubrium. Great care must be exercised in dislocating these retrosternal goiters or else serious hemorrhage or pneumothorax may result.

diffuse forms of goiter, as well as the intrathoracic goiter, cannot be recognized by inspection. This applies particularly to the soft follicular and parenchymatous type, especially when they are not large and

Fig. 554.—Goiter of the Isthmus. These goiters can be removed through a very small collar incision.

the patient has well-developed muscles of the neck. It is in such cases of goiter that the functional symptoms which chiefly attract attention are so often thought to be due to a variety of causes and treated accordingly. The up-and-down movement of the tumor during deglutition, which is characteristic, can usually be seen a considerable distance from the patient. The movement is due to the close connection between the external capsule of the goiter and the trachea and esophagus. In cases in which it is difficult to palpate the goiter, the tumor may be rendered more palpable and visible by having the patient cough. In retrosternal goiter the tumor can often be seen and felt only when the patient coughs. Most goiters can be moved rather freely in the surrounding tissue, the mobility being much greater in the lateral directions than up and down.

Percussion and auscultation are frequently of value in the diagnosis of intrathoracic goiter. Quite marked dulness with a rounded lower border and beginning at the upper aperture of the thorax, is usually present. Percussion and auscultation of the larynx and trachea yield dulness on the side of the goiter and diminished tracheal breathing, which are suggested by Kocher as being important diagnostic signs in struma intrathoracica.

The differential diagnosis between goiter and a branchial cyst is usually not difficult, the latter being more regular in outline, appearing as a smooth, soft, spherical mass without symptoms and growing very slowly. Fluctuation is usually distinct and the thyroid gland can usually be palpated separately from the cyst.

Lymphosarcomata may develop in any location of the neck. When located anterior to the sternomastoid muscles they may appear in the region of either lateral lobe of the thyroid. The mass, however, is usually more definitely lobulated, and frequently the involved individual glands can be palpated. The mass is not as movable as a goiter and does not move up and down with the larynx during deglutition.

Enlarged lymph glands due to leukemia or pseudoleukemia are not apt to be mistaken for goiter for the same reason as given in connection with lymphosarcoma and because they usually appear high in the neck and not in the region of the thyroid.

Treatment.—Goiter is a disease which has a tendency to progress indefinitely unless it is controlled by medical or surgical treatment or by change of climate or by diet. In a large percentage of cases, especially in children and young adults, the treatment belongs to the internist. The early simple hypertrophy will usually subside by the administration of some form of iodin, with the judicious use of thyroid extract. Space forbids the discussion of internal treatment further than to say that appropriate internal treatment must be based upon an accurate investigation of the goiter and the patient. In the past much harm has been done by the indiscriminate use of iodin preparations and thyroid extract. It is also important to investigate various sources of infections, such as decayed teeth, infections of the various sinuses and especially infected tonsils, and if any of these are present they should be taken care of as the first step in the treatment. During the past two years the author has found that in children and in young adults who have come under our care with goiters the vast majority also had infected tonsils. Such tonsils should be removed, and then if the case is one in which it seems likely that relief can be obtained without further surgical interference, appropriate medical treatment should be instituted.

Indications for Surgical Treatment.—In the vast majority of cases of simple goiter the indications for surgical treatment can be determined primarily instead of treating them with internal medicines first and referring them to the surgeon only if the internal treatment fails.

1. All goiters producing pronounced pressure symptoms should be treated by operation.
2. Nodular goiters, especially those in the process of secondary degeneration, seldom are amenable to medical treatment. These degenerative processes can usually be determined by the changes in their consistency. Thus the nodular colloid, the fibrous, calcareous, and cystic nodular goitres are surgical.
3. Operation is indicated in all cases of simple goiter showing any toxic symptoms, and in many cases because its uninterrupted course involves considerable risk of future development of toxemia or malignancy.
4. Large, diffuse colloid goiters should be removed and the smaller diffuse colloidal enlargements may be considered surgical after they have resisted a thorough iodin medication.
5. The removal of adenomata is desirable, especially as a prophylactic measure against toxemia, as they seldom if ever disappear spontaneously, and, according to Plummer, at least 25 per cent. of adenomata ultimately develop well-marked signs of pressure or thyrotoxicosis.
6. In a small percentage of cases goiters may be removed for cosmetic reasons only.

Operative Measures.—There are various operative measures such as:

1. Excision (Kocher).
2. Enucleation (Porta and Socin).
3. Resection (Mikulicz).
4. The combined methods.
5. Exenteration (Kocher).
6. Ligation of arteries (Nolfler).

Excision.—In probably 30 per cent. of cases of simple goiter the growth is confined to one lobe in the form of multiple adenomata or a single encapsulated adenoma or cyst. In such cases an excision of the involved lobe, together with the isthmus, leaving only the posterior capsule of the gland to protect the parathyroid and recurrent laryngeal nerve, is the operation of choice. When besides the marked enlargement of one side there is also a similar involvement of the opposite side, it is well to make a complete excision of the larger lobe and a resection of the smaller side, together with the isthmus.

Enucleation.—In some cases of single or multiple encapsulated adenomata they may readily be enucleated, thus preserving the remainder of the thyroid. This is readily accomplished by simply elevating the lobe of the gland, making an incision through the capsule at the point where the tumor presents and then shelling out the tumor from the gland. The thyroid should be kept elevated and under some tension to control the bleeding. A fine catgut suture is passed through and through the thyroid, obliterating the space from which the tumor has been removed, and at the same time controlling the hemorrhage.

Resection.—In large colloid goiters it is often well to make a double resection, removing the greater portion of both lobes. After the gland has been exposed and both lobes dislocated a large wedge-shaped portion of the gland on either side is cut away and the two surfaces of each lobe are brought together by a running catgut suture, which also controls the hemorrhage. The isthmus should either be divided or removed to permit the two edges of each lobe to come together more readily. When the operation is completed the remaining portion resembles somewhat a normal thyroid lobe.

Exenteration.—Exenteration, as suggested by Kocher, is a method of reducing the size of the gland, in some cases of large colloid goiter, by exposing the gland, opening its capsule and curetting away all of the soft colloid material, then suturing the capsule.

Ligation of Arteries.—Ligation of arteries is seldom indicated in simple goiter. It is sometimes of value in small vascular goiters, but it is most often employed as a preliminary operation in Grave's disease. It may, however, be used to advantage in cases of simple goiter in combination with excision, in cases showing mild toxic symptoms where the enlargement is confined to one lobe or the other lobe is only slightly involved. In such cases it is advisable to make an excision of the large lobe and isthmus and to ligate the superior vessels on the opposite side. By this plan the patient is more likely to obtain complete relief than by the simple excision of the one lobe.

NON-HYPERPLASTIC TOXIC GOITER.

This group includes a class of patients suffering from goiter which have existed for a considerable time, often many years, without producing any recognizable symptoms, when gradually degenerative symptoms develop, especially those of the cardiovascular system. These symptoms have been attributed to various causes, all of which, so far, are simply speculations. Kocher has drawn attention to the fact that occasionally during the treatment of simple goiter with iodin severe symptoms of intoxication develop. The author has encountered this same condition several times. It is probable that the symptoms are due to the absorption of some toxin, but until we know what the toxin is we must still remain in the realm of speculation. For all practical purposes it is sufficient to know that the toxin is developed in the thyroid gland and that many simple goiters may and will develop into toxic goiters. Plummer has shown there is sufficient evidence to prove that these patients comprise a group distinct from the exophthalmic goiters, and that they rarely develop into cases of Graves's disease.

This group of cases has a more or less constant train of symptoms, with varying degrees of intensity. The symptoms come on very gradually, the first and most constant of which is tachycardia. Plummer[1] found, in a large series of cases, that patients in this group gave a goiter history beginning at twenty-two years of age, and that the first symptoms of intoxication appeared at 36.5 years of age. Corresponding ages for patients with exophthalmic goiter was 32.9 years, that is, the symptoms appeared shortly after the goiter was discovered.

In the non-hyperplastic group the symptomatology varies greatly from very mild to extreme condition. Many times the patient consults the physician about a goiter because of its size and is not conscious of the gland having produced any intoxication, but early cardiovascular changes can be demonstrated. Myocardial changes predominate and in long-standing cases may be more marked than in true exophthalmic goiters. In the majority of cases, besides tachycardia, nervousness and tremor are present, but develop slowly and are less marked than in the hyperplastic group.

The course of the disease is one of a mild toxemia persisting without marked exacerbations, such as occur in true exophthalmic goiter; thus the continued poisoning has a tendency to lead to irreparable damage to the heart and to the kidneys. The thyrotoxicosis varies greatly in degree in different cases. Oftentimes it is so mild that, except for tachycardia, slight muscular weakness and mild nervous symptoms, these patients suffer very little inconvenience for a long time. Vasomotor signs frequently develop, but usually in a lesser degree than in Graves's disease. Occasionally, however, the symptoms are so marked that it is difficult to differentiate between this form of toxic goiter and a true exophthalmic case.

The pathological findings in this group are not constant other than that hyperplasia of the gland is not present. In the majority of cases the pathological picture resembles that of simple goiter, and the assumption is that the toxemia is frequently due to the absorption of products from degenerated areas in the gland.

Treatment.—The indication for treatment in this group of cases is very definite. The condition being due to a toxic process which gradually progresses, the rational treatment consists in removal of the source of the toxemia, the thyroid gland. The operative procedure in mild cases is similar to that in cases of simple non-toxic goiter, and in the later cases to that of true Graves's disease, which is discussed in detail on page 793.

The results from surgical treatment are very satisfactory if the operation is performed early before irreparable damage has been done to the heart and kidneys. Even in the late cases, although the operation is accompanied by some risk, surgical interference is indicated to cut off the source of the intoxication, thus giving the patient a chance for at least partial recovery.

[1] Jour. Am. Med. Assn., 1912.

Too much stress cannot be placed upon the early diagnosis and the importance of an early operation in all cases of hyperthyroidism in adults with this gradual progressive type. Early operation is not only important because of the better chances of a complete cure, but it eliminates practically all the risk of the operation, as the dangers depend largely upon the amount of harm done before the operation.

Careful judgment is required in these cases in determining the amount of thyroid tissue to be removed, the object being to preserve only just enough to prevent supervening hypothyroidism. In the late cases, with marked cardiac and renal changes, great care is required in the entire surgical management. This is taken up in detail later under the treatment of cases in Group IV.

It is well to bear in mind that in girls at about the time of puberty, or a little later, many goiters cause symptoms of a toxic nature. There may be present tachycardia, tremor, muscular weakness, nervous excitability and other minor symptoms. There may also be present even a slight degree of exophthalmos. Many of the patients will make a good recovery under proper medical management. In brief, the treatment indicated is removal of any focus of infection, such as infected tonsils, which is often found in these cases, then the institution of complete rest, physical, mental and emotional; a diet composed largely of milk, cooked vegetables and fruits: favorable hygienic surroundings and the avoidance of all condition which might cause nervous excitement.

HYPERPLASTIC ATOXIC GOITERS.

The hyperplastic atoxic thyroids are so extremely rare that it is not necessary to consider them clinically. In a large series of cases, Plummer[1] found, that of the hyperplastic goiters coming to operation only 0.8 per cent. did not give the clinical symptoms of exophthalmic goiter. Since Wilson called attention to the relationship between hyperplasia of the thyroid and exophthalmic goiter we have made a routine microscopic examination of all the goiters removed, and in every case evidence of hyperplasia has been found in some portion of the gland.

HYPERPLASTIC TOXIC GOITER (EXOPHTHALMIC GOITER).

Hyperplastic toxic goiter, exophthalmic goiter or Graves's disease is characterized by a rather definite train of signs and symptoms, the most prominent of which are tachycardia, exophthalmos, muscular tremor and weakness, vasomotor affection, disorders of metabolism, with many other manifestations of disturbances of the nervous functions. There seems to be a definite relation between the clinical and pathological findings in this group, as the disease is practically always associated with hyperplasia of the parenchyma of the thyroid. This disease was described by Parry[2] over a century ago, and again in 1835

[1] Jour. Am. Med. Assn., 1912.

[2] Quoted by Ochsner and Thompson, Thyroid and Parathyroid Glands, 1910.

Graves[1] described all the clinical symptoms so clearly that it became known as Graves's disease. While very little is known of the etiology of exophthalmic goiter, the theory advanced by Moebius[2] in 1886 is still quite generally accepted, that is, that in this disease there is an absorption of some toxic substance secreted by a diseased thyroid gland which enters the general circulation through the lymphatic system. There is, however, no definite knowledge as to what prompts the thyroid to this hyperactivity or as to the nature of the toxin concerned or as to its mode of action in producing the various constitutional symptoms. In our own cases at the Augustana Hospital, in the majority of instances, it has been possible to demonstrate even in the gross specimen some portion that showed hypertrophy, and, histologically, practically every specimen showed typical tissue in some

Fig. 555.—Very small toxic goiter, exophthalmos. Note the excellent delineation of the neck muscles and the tension with which they are held indicating the degree of nervous tension the patient lives under.

portion. The clinical symptoms do not necessarily correspond with the extent of goiter, as thyroids containing only a small portion of diseased tissue may produce the most severe symptoms. When one bears in mind the fact that any one of a number of active drugs, with which everyone is familiar, may produce violent symptoms when introduced into the circulation, it is possible to suppose that the toxin from even a small portion of a diseased thyroid may produce the various symptoms of this disease. It is not uncommon to have a marked difference in the size of the thyroid from time to time, also in the same manner the severity of symptoms varies greatly.

There seems to be a discharge into the circulation of a considerable

[1] System of Clinical Medicine, Dublin, 1843

[2] Schmidt's Jahrb. d. in. und aus. gesamt. Med., 1886.

quantity of the poison at intervals. These exacerbations may occur without any apparent cause, or, on the other hand, may follow sudden mental or physical influences.

It is not uncommon for sorrow over the death of some member of the family, excitement over a fire, sudden fright, etc., to give rise to very severe and sometimes even a fatal exacerbation of this disease.

Plummer[1] in describing the course of the disease represents it by a curve, the greatest height of the intoxication is found to be reached during the latter half of the first year, and then rapidly drops to the twelfth month. In many instances it reaches the normal base line during the next six months, more often it fluctuates with periods of exacerbation for the next two to four years. Secondary symptoms and exophthalmos may remain, but the active course rarely continues over four years without distinct intermissions. The ascent may be gradual, sudden or irregularly marked by many secondary curves.

Etiology.—Exophthalmic goiter is far more common among women than men, and almost always shows itself first during early adult life. Balfour[2] in an analysis of 2928 patients with exophthalmic goiter found "that 85 per cent. were females and 15 per cent. were males. About 10 per cent. were under twenty years of age. The age of onset was usually from twenty-five to thirty-five years; the average age at which symptoms were noticed by the patient was thirty-two years. The youngest individual was a girl, aged four years, and there were five cases under ten years of age, all being girls."

There seems to be no one etiological factor which may be attributed as a cause in any considerable number of cases. In connection with the infection theory the writer has noticed that in a considerable number of cases of Graves's disease there is present more or less infection in the mouth, teeth, nose and especially in the tonsils.

A great many patients attribute their first symptoms to some psychic disturbance, usually a shock to the nervous system, or excessive mental or physical strain. Moebius's theory that the disease is due to excessive secretory activity of the thyroid gland is still accepted by many observers.

Kocher has shown experimentally in animals that Graves's disease could be produced by the injection of thyroid extract, thyroid substance of iodothyroidin, substantiating the theory that the disease is a hyperthyroidism. The fact that iodin therapy regularly increases the severity or the symptoms and that excessive iodin treatment in simple goiter frequently is responsible for the development of exophthalmic goiter, would also bear out the correctness of this theory.

Crile[3] believes that exophthalmic goiter is a "disease of the motor mechanism that causes physical action and expresses the emotion; its origin is in phylogeny and its excitation is through some stimulating emotion, intensely or repeatedly given, or some lowering of the

[1] Keen's Surgery, vol. vi.
[2] Mayo Clinic, 1914, vol. vi.
[3] Phylogenetic Association in Relation to Certain Medical Problems.

threshold of the nerve receptory, thus establishing a pathological interaction between brain and thyroid."

Symptoms. — CIRCULATORY DISTURBANCES. — 1. *Tachycardia.* — Tachycardia is one of the earliest and most constant signs of exophthalmic goiter. This condition usually exists for a considerable time, unknown to the patient, and when discovered, is usually considered "palpitation" and not thought to be constant. While the rapidity of the pulse varies greatly from time to time, according to the degree of toxemia, and with physical activity and mental strain, there is always present some degree of tachycardia. Early in the disease the pulse ranges from 100 to 120 beats per minute. In many cases of Graves's disease the thyroid is not greatly enlarged—in fact, its size is not noticeable. In such cases, in the absence of exophthalmos and the prominence of the tachycardia, the true condition is frequently overlooked and the case erroneously diagnosed as one of functional heart disorder. After the disease is well established the pulse-rate varies from 130 to 160 beats per minute, and is usually accompanied by visible pulsation of the vein of the neck. Continued hyperactivity of the heart eventually results in permanent changes in the cardiovascular system. Tachycardia is always associated with excitability, and often irregularity and palpitation.

2. *Murmurs of the Thyroid.*—Vascular arterial murmurs of a swirling character are often obtained by auscultation directly over the enlarged gland. Putnam[1] states: When present it is probably pathognomonic, but sometimes it may be heard only over limited areas. This murmur should be distinguished from the "hum" due to compression of the cervical veins. In exophthalmic goiter the presence or absence of a definite thrill over the superior thyroid vessels is one of the most important physical signs upon which a diagnosis may be based. A definite thrill is very often met with in hyperplastic or exophthalmic goiter, but is rarely, if ever, present in non-hyperplastic goiter.

Pulsation of the gland itself frequently is visible and may be accompanied by a palpable expansion and bruit. Many patients are conscious of a constant throbbing sensation in the region of the thyroid—in fact, they often complain of this as their most annoying symptom.

3. *Cardiac Signs.*—The heart sounds are accentuated, due to the excited and accelerated action of the heart. Blood-pressure may be a few millimeters above normal, but in general it is low. Sooner or later in exophthalmic goiter there is evidence of damaged heart muscle. Secondary dilatation is frequent and is often accompanied by loud systolic murmurs. The palpitation, which is usually marked, may cause the patient great anxiety. This palpitation may be continuous and persistent, or it may be intermittent, appearing without any apparent cause, or may be precipitated by any psychic influence.

General evidences of cardiac insufficiency may be present, such as dyspnea and anasarca. The degree of cardiac involvement has much

[1] Sajous's Analytic Cyclopedia of Practical Medicine, vol. v.

to do with the final outcome of these cases, the determination of which has more bearing upon the prognosis than any other single symptom.

NERVOUS PHENOMENA.—1. *Nervous Excitability.*—In the majority of cases cerebral excitement in some form is usually referred to as nervousness. The degree of excitement varies greatly, is characterized by a mental restlessness; in many patients their actions resemble very much those of a person under the influence of a stimulating intoxicant. Besides the mental unrest, there is often present a motor activity producing choreiform movements. As pointed out by Tinker, these patients often complain of a symptom which could readily be mistaken for typical globus hystericus, and which has often caused various observers to make a diagnosis of hysteria in patients suffering from exophthalmic goiter. In severe acute hyperthyroidism the cerebral manifestations may resemble those of a patient suffering from delirium tremens. In these cases the intoxication is usually severe enough to result in death.

2. *Mental Irritability.*—Mental irritability is one of the most constant and early symptoms of exophthalmic goiter, and is but a variation of the cerebral excitability. The patients become annoyed over trivial things, which formerly would not have been noticed by them. They frequently have a dread of being in the presence of other persons: even members of their own families seem to annoy them. Mental irritability often appears early in the history and is frequently an important indication of the degree of intoxication.

3. *Mental Depression.*—Late in the disease a certain proportion of these cases become mentally depressed, presenting a picture of melancholia. This is one of the most definite evidences of the existence of a marked toxemia, and often is of serious import.

4. *Tremor.*—Tremor is almost invariably present and occurs early in the disease. It is fine and rapid, eight to ten oscillations per second, and appears first in the hands, then later in the head and other portions of the body. When associated with marked muscular weakness the tremor may appear as being coarse instead of the fine tremor as described above. The similarity between the tremor of chronic alcoholism and that of exophthalmic goiter further supports the theory of Moebius, that the disease is due to a condition of poisoning through toxic substances circulating in the blood and affecting the tissues directly. This symptom is most easily elicited by having the patient extend the arm to a right angle with the body, having the fingers extended and separated. In many patients tremor is an early symptom, and it may be the tremor that first causes them to consult the physician. It is important to always bear in mind the relation between this symptom and exophthalmic goiter. The tremor remains constant after it has made its appearance, but varies greatly in its severity. Occasionally in patients who have suffered from the disease for a considerable time; there are present mild contractions of the muscles resembling those of incipient chorea. These contractions affect the head especially, but sometimes also the upper extremities.

5. *Muscular Weakness.*—Muscular weakness may be looked upon as one of the cardinal symptoms of exophthalmic goiter. It is always present, but in varying degrees, being exceedingly marked in some cases. At the history-taking the patients usually volunteer the information that they "tire easily." Associated with the muscular weakness there is usually a loss of weight; this, however, depends upon the degree of intoxication. It may show itself simply by the fact that the patient becomes fatigued more easily than normal, or it may be so severe that the patient suddenly loses control of certain muscles and may drop things suddenly. This weakness is usually most marked in the lower extremities and is often most marked in the hamstring muscles. Many patients first notice this condition from difficulty in going down stairs, and also notice in changing from the standing to sitting position that unless they steady themselves with their arms they will drop into the seat suddenly instead of gradually, as they had expected to do. This weakness seems to be due to a condition of the muscle tissue itself, caused by the poisonous thyroid secretion circulating in the blood. This same condition affecting the muscles of the orbit and of the eyelid probably have much to do with producing the symptom of exophthalmos and many other ocular symptoms.

Ocular Signs.—1. *Exophthalmos.*—Exophthalmos, even though it is the sign which gave the disease its name, is often lacking. This sign is usually present in advanced cases, although it almost always is preceded by a number of symptoms. It is nearly always present in acute cases, and is especially marked when the symptoms are brought on by some intense emotional excitement.

Retraction of the eyelid may be present without exophthalmos, the staring giving a false impression of protrusion of the eyeball. The degree of protrusion may vary from time to time with the other symptoms, sometimes being so great that the eye is nearly dislocated from the socket. It is likely that the protrusion of the eye is due to a weakened and relaxed condition of the muscles which normally keep the eyeball in place, together with an engorgement of the veins in the orbit. Early in the disease the protrusion may appear suddenly and then subside just as rapidly. This fact strengthens the theory that a congestion or engorgement of the vessels in the orbit aid in pushing the eyeball forward. Later on the eye becomes fixed, the protrusion remaining constant, with only slight variations in degree. Exophthalmos is often greater on one side than the other, the right eye usually being the more prominent. The fact that the right lobe of the thyroid is usually involved to a greater extent than the left in exophthalmic goiter, would suggest that the two phenomena are in some way related. It occasionally happens that the larger lobe of the thyroid and the more protruding eye are on opposite sides.

Minor Eye Signs.—1. *Von Graefe's Sign.*—In directing the eye downward the lower margin of the upper eyelid does not follow the line of vision as normally but lags behind and follows in an irregular spastic manner.

2. *Stellwag's Sign.*—The eyes have a peculiar staring appearance when fixed on an object and often have a peculiar shiny look. Infrequent and incomplete winking is also noticeable.

3. *Dalrymple's Sign.*—A widening of the palpebral fissure.

4. *Moebius's Sign.*—An insufficiency of convergence and lack of accommodation at near-point.

These signs all occur with varying degrees of frequency, von Graefe's and Stellwag's being most constant. They are probably all due to the weakening of the eye muscles, due to the poisoning caused by the hyperthyroidism.

Vasomotor Disturbances.—1. *Sweating.*—The most common vasomotor sign is sweating, which is noticed early in the disease, often is very excessive and involves principally the palms of the hands, axilla and feet. It may also be generalized as a mild hyperidrosis.

Flushing and high vascularity of the skin, "dermotography," is very common. Pulsations of the larger vessels of the neck are quite noticeable and appear quite early.

Blotchy erythema, involving principally the neck and upper chest, is a common phenomenon. The slightest excitement or manipulation, such as that occasioned by an examination, is sufficient to make this sign very noticeable. Blushing, which so often occurs in exophthalmic cases, is often very annoying, because of the fact that the slightest mental excitement will bring about this condition.

2. *Edema.*—In a considerable number of patients a localized edema may be observed. It is frequently of the fleeting type, appearing suddenly and disappearing within a few hours, or it may persist for days or weeks. These edemas are usually of the non-pitting type and may be due to localized circulatory changes, or perhaps are associated with a myxedematous tendency. The eyelids, one or both, are rather prone to edema, which condition usually remains rather constant.

3. *Skin.*—The skin often reveals important phenomena which vary greatly in different individuals. In some patients the skin becomes thin and translucent, the finger-nails crack and become lined with longitudinal furrows; the teeth become brittle. The hair becomes somewhat lighter in color and falls out. The eyelashes are the first to show the atrophic changes, becoming short and brittle, and fall.

In some cases there is a marked degree of darkening of the skin, giving it a smoky or dirty color. In others, especially in dark individuals, the pigmentation of the skin is marked, resembling the discoloration in Addison's disease. The areas about the nipples, axilla, lower portion of the abdomen and inner surfaces of the thighs, are usually darker than the remaining portion of the body. On the face the most marked portion is about the eyes and is present in a large proportion of cases.

Metabolism.—The general metabolism is affected to some extent: the tendency to emaciation is not great, except in the severe acute cases. In many of the mild cases the weight may remain unchanged or may even increase. Temporary attacks of indigestion, accompanied by vomiting without any apparent cause, are common in advanced cases. Later a persistent vomiting and diarrhea may occur and persist indefinitely, as either one is seldom controlled by medication. These conditions are probably due to the effect of the toxin on the gastro-intestinal tract and usually follow the course of the general manifestations of the disease.

Blood Findings.—Kocher[1] believes that the blood picture is pathognomonic, so that the diagnosis can be made from the blood picture even in abortive forms of the disease. His findings are as follows: The number of the different varieties of normal leukocytes undergoes alteration, and the number of leukocytes, as a whole, is slightly diminished. The neutrophile leukocytes, which are most numerous in normal blood, are diminished to sometimes half their normal number, so that they may be less numerous than the lymphocytes; the latter are increased sometimes to twice the normal number, and even if there is no absolute increase there is always a relative augmentation. The eosinophile leukocytes are usually also diminished, but may be slightly increased, particularly in cases that are not uncomplicated. The number of red cells is almost always normal, as is also the percentage of hemoglobin. The viscosity of the blood is usually lowered, so that it coagulates more slowly.

Other observers in a routine examination of the blood have found an increased lymphocytosis, but have not been able to substantiate Kocher's statement sufficiently to feel that the diagnosis can be made from the blood findings alone.

Diagnosis.—There is no difficulty in the diagnosis of a typical case of exophthalmic goiter. The doubtful cases are those seen early in the course of the disease, especially when many of the major symptoms are wanting. There is perhaps not a single symptom, except possibly tachycardia, which may not be absent or so inconspicuous as not to attract attention. If the rapid pulse is ever absent it is extremely rare, but it is not uncommon for the pulse-rate to be about ninety early in the disease. It is at times a difficult matter to determine whether in a young woman who has a slightly enlarged thyroid, some mild nervous manifestation and a rapid heart the picture is one of an early hyperthyroidism, some psychic manifestation or simply neurasthenia. A careful history and thorough examination will, however, usually differentiate these conditions. Persistent tachycardia, even though not marked, persistent nervousness, excitability and tremor not associated with typical signs of neurasthenia or out of proportion of those signs, persistent even though slight suffusion of the face, should always direct one's attention to the thyroid, and especially so if the patient has had an indolent goiter for several years. Fortunately for the patient one or more of the major symptoms will be found in almost every case which will clear up the diagnosis.

Treatment.—The treatment of exophthalmic goiter may be considered as both surgical and non-surgical. A great many methods have been

[1] Keen's Surgery, vol. iii.

used in the treatment of Graves's disease, a number of which have had enthusiastic supporters. The various successes obtained by different observers probably do not depend upon the specific medical measures used but on the fact that a certain group of cases suffering from Graves's disease will recover by the well-established rule of rest, both mental and physical, and the removal of any foci of infection that may be present. There is still another small percentage of cases that will recover from their acute symptoms without any medical management and remain in a fair degree of health for a long time. In no other way can we explain why it is that one observer insists upon the importance of the treatment of the intestinal tract, another on that of the nervous system, another on the thyroid, etc., with apparent cures occasionally from each method. Rest, above all, combined with the treatment of special symptoms and a well-regulated diet is the most important element in the non-surgical treatment of exophthalmic goiter.

Among the many forms of medical treatment which have been more or less successful may be mentioned the use of quinin hydrobromate and belladonna, bromides and phosphorus preparations, serum from thyroidectomized goats, the Beebe and Rogers serum, lactic acid ferments, various injections into the gland and *x*-ray exposures. No one measure has given sufficient consistent results to make it any more than of questionable value.

In all types of goiter, especially in children, the author considered it important to remove the tonsils, or any other foci of infection that may be present, as a preliminary to whatever other treatment may be contemplated.

Alvarez[1] says that the physician in the absence of the surgeon can do little more for the patient with exophthalmic goiter than he could in the time of Parry, Graves and Basedow.

Surgical Treatment.—Surgical interference is indicated in all well-marked cases of exophthalmic goiter, provided the patient's condition warrants it. Careful judgment, however, is required to determine when to operate; just what to do and how much to do in each individual case. The preoperative and postoperative management is also of the greatest importance in the surgical treatment of exophthalmic goiter.

In the milder toxic cases, whenever improvement from hygienic, dietetic and medical treatment, together with rest, is only of temporary duration, then operative treatment is strongly indicated, because in these cases the prognosis is usually excellent if the surgical treatment is employed before the patient has suffered too many recurrences. The recovery after surgical treatment will be much more perfect if the operation is performed before the heart and other organs have suffered severely from the repeated floodings of the circulation with thyroid poison. The surgical treatment of exophthalmic goiter is based upon a fairly well-established theory that the symptoms are due to an excessive

[1] Quoted by Hazzard, Jour. Tennessee State Med. Assn., September, 1911.

secretion of an abnormal thyroid which is proportionate to the extent of hyperplasia in the gland.

The mortality following operation for exophthalmic goiter has been lowered greatly in the past few years. This lessened mortality is probably due not so much to better methods of operating or better skill as to better judgment of the proper time to operate. It is not uncommon for patients to be in an extreme condition when they are brought to the surgeon. Operation undertaken upon such patients is sure to result in a very high mortality.

The author's experience has been the same as that of C. H. Mayo, that is, that an emergency operation is never called for in exophthalmic goiter. These cases practically never suffer from severe pressure symptoms, and in any given case in which the toxic condition is severe enough to cause alarming symptoms an emergency operation would undoubtedly result fatally. On the other hand in many of these extreme cases the acute exacerbation will subside under complete mental and physical rest, when surgical treatment may be carried out with comparative safety.

Anesthesia.—The question between general and local anesthesia is still an unsettled one. Some authors consider general anesthesia the greatest danger in thyroid operations, especially for the relief of exophthalmic goiter, and consequently insist upon operating only under local anesthesia. On the other hand, some observers think that the harm done to the sensitive nervous system during the use of local anesthesia is much greater than the harm of a carefully administered general anesthetic. This view is supported by Moebius, the author of the theory of hyperthyroidism in exophthalmic goiter.

For operating upon all simple uncomplicated goiters and most cases of exophthalmic goiter, the writer has found a properly administered general anesthetic to be as safe and practical as for other general surgery, and considers it the method of choice in most cases of thyroidectomy. For this purpose ether should be used and given very slowly by the open drop method, but not to the stage of profound anesthesia. Local anesthesia is indicated in many cases of complicated goiter when there is a marked tracheal pressure in nephritis and other general conditions that are unsafe under a general anesthetic. The operation of ligation of thyroid vessels may best be done under local anesthesia. In some nervous, excitable patients with exophthalmic goiter, Crile's anoci-association plan can be used to advantage, which is carried out as follows: (1) Patients are treated in the hospital several days before the operation is to be performed and are left in ignorance as to the time of operation. Morphin and scopolamin is administered hypodermically one hour before operation. (2) Ether or gas is substituted for inhalation of aromatics, which have been a part of the preparatory treatment. (3) Local anesthesia is used in the field of operation to prevent deleterious impressions from being conveyed to the brain, thus lessening the amount of general anesthetic used. As a matter of fact, these patients tell each other beforehand concerning the method each surgeon is in the habit of employing, so that they are as fully informed about this mystery as they are about the reindeer that draw the sleigh that brings Saint Nicholas and the Christmas presents, usually months before the vicious thyroid gland is to be taken away from them.

The author uses the plan of anesthesia as advised by Ochsner, which is as follows: The patient is given from $\frac{1}{6}$ grain to $\frac{1}{4}$ grain of morphin, together with $\frac{1}{150}$ to $\frac{1}{100}$ grain of atropin, three-quarters of an hour before the time of operation. The preliminary use of the morphin and atropin accomplishes three things: (1) it has a quieting influence upon the patient; (2) the quantity of ether required to produce relaxation is reduced to a minimum and the anesthesia persists a considerable

Fig. 556.—Showing the position of patient on the table properly placed for goiter operation.

time after the administration of ether has been stopped; (3) it lessens the secretion in the pharynx, thus preventing the accumulation of mucus in the throat during the operation from manipulation about the trachea.

The ether is administered by the open-drop method until the patient is fully anesthetized, when the patient is ready for the operation. Just before the operation is begun the ether mask is removed and a pad, composed of several layers of sterile gauze, is placed transversely across the nose and mouth, preventing the patient from breathing or coughing into the wound. The head of the table is now elevated and the lower end depressed, so that the patient is in the inverted Trendelenburg position (Fig. 556). This results in a sufficient anemia of the brain so that the operation can readily be completed without the administration of any additional anesthetic. This position has the further advantage of reducing the hemorrhage. In order to keep the respiration unobstructed an assistant lifts the jaw forward and at the same time holds the gauze pad in place over the mouth. A small pillow placed under the shoulders causes the anterior region of the neck to become prominent.

The advantages of administering ether in this manner are several. (1) The patient is relieved of all nervous and mental irritation; (2) the administration of ether having ceased before the operation is started, the surgeon can concentrate his entire attention upon the operation itself; (4) there is no danger of infection from the mouth or by the anesthetist during the operation; (5) so small an amount of ether is used that nausea and vomiting rarely occur; (6) it is usually possible to give these patients hot water to drink almost immediately after the operation; (7) patients do not inspire mucus, which is often very troublesome when the anesthetic is continued throughout the operation.

In all cases of exophthalmic goiter, gastric lavage is practised immediately after the conclusion of the operation with water at 105° F. This has the effect of stimulating the patient and removing any mucus or bile that may have accumulated in the stomach. In cases suffering from severe hyperthyroidism at the time of operation the gastric lavage seems to eliminate postoperative hyperthyroidism.

Danger of Operation.—1. *Anesthesia.*—Accidents from anesthesia during operation upon the thyroid gland have not been uncommon. Many authors consider general anesthesia the greatest danger, especially in operation for exophthalmic goiter. If general anesthesia is avoided in cases with marked tracheal pressure, and when used is given only to the extent of light anesthesia, or if administered after the plan of Ochsner as given above, accidents from anesthesia will be extremely rare.

2. *Postoperative Hyperthyroidism.* — The greatest real danger to patients from operation upon the thyroid is from postoperative hyperthyroidism, due either to the absorption of thyroid secretion pressed out of the gland into the circulation during the operation or by absorption of thyroid secretion or toxic blood from the wound surface. The danger of postoperative hyperthyroidism can be eliminated to a great extent: (1) By doing as rapid an operation as is consistant with good surgery; (2) by avoiding squeezing and rough handling of the gland and carrying out the entire operation with as little trauma as possible; (3) by controlling hemorrhage completely, leaving the wound as dry as possible; (4) by providing free drainage, so that any oozing of the blood and serum may have easy escape and not remain in contact with the absorbing surfaces, and by the use of gastric lavage at the conclusion of the operation as indicated above.

3. *Shock.*—The element of shock, which formerly was looked upon as a grave danger in goiter operations, has been practically eliminated

by the improved methods of technic. If the surgeon uses good judgment in selecting the proper time to operate, especially in exophthalmic cases, and then does the operation with reasonable skill, avoiding trauma of the tissues, and if the vessels are secured before they are severed, thus reducing the loss of blood to a minimum, the element of shock need not be feared.

4. *Hemorrhage.*—Undue loss of blood increases shock in three ways: (1) by prolonging the operation; (2) by increasing the amount of manipulation; (3) by the loss of blood itself. Kocher claims that the blood itself in exophthalmic cases has a considerable degree of toxicity, so that the patients whose wound surfaces have been free from blood make better recoveries than those in whom the surfaces have been drenched with blood. In avoiding hemorrhage it is important to remember that the veins are thin-walled and are usually dilated to several times their normal size. Great care must be used in securing and ligating them, because, on account of their size, a small tear results in a considerable loss of blood.

5. *Injury to the Parathyroid Glands.*—Since the importance of the parathyroids was generally recognized, injury or removal during operation is extremely rare, because of the ease with which they may be avoided. The parathyroids, four in number, two on either side, are situated behind the capsule of the thyroid. In making the excision of a lobe of the thyroid its posterior capsule should be left in position and not removed from the thyroid. If this one simple measure is adhered to there will be no difficulty in preserving the parathyroids.

6. *Injury to the Recurrent Laryngeal Nerves.*—The recurrent laryngeal nerves lie posterior to the capsule of the thyroid along the side of the trachea, consequently the precaution of leaving the posterior capsule of the thyroid will serve to prevent injury to the nerves as well as to the parathyroids. The danger of injuring the nerve while securing the superior thyroid vessels is not great, as the nerve is a considerable distance from the point where the vessels enter the capsule of the thyroid. At the lower pole of the gland greater care must be used in securing the inferior thyroid vessels. If the forceps, grasping the inferior vessels, are placed forward on the capsule instead of toward its posterior surface there will be no danger of injuring the nerve.

7. *Collapse of Trachea.*—If the tracheal rings are normal there is no danger of collapse of the trachea during operation upon the thyroid. Occasionally, from continued pressure by the goiter, a pressure atrophy of cartilages of the trachea takes place, resulting in a softening and almost complete disappearance of the tracheal rings. In such cases the trachea is likely to collapse as soon as it has lost its support from its attachment to the thyroid gland. When this happens an immediate asphyxia takes place, and the more violent the efforts at inspiration the more complete will be the obstruction. Attempts should be made to insert two sharp tenaculæ into the collapsed portion of the trachea to draw the latter forward. If this fails to give relief a longitudinal incision should be made in the trachea and a tracheotomy tube inserted.

In the removal of a substernal goiter there is danger of asphyxia from pressure on the trachea, as the tumor is dislocated upward.

8. *Injury to the Pleura.*—Occasionally, during the removal of substernal goiters, an opening is made in the pleura. If this happens the substernal space should be packed immediately with a piece of gauze, the end of which is brought out of the drainage opening in the skin and is left in place for three days. The author has never seen any unfavorable complications occur in these cases.

The selection of the time to operate is of the greatest importance. The course of exophthalmic goiter is one of many periods of fluctuation from mild to almost moribund conditions, and in choosing a time to operate the periods of exacerbation should be avoided. During periods of exacerbation all cases should be considered as medical cases. In many advanced cases, even in the periods of slight remissions, their condition is so extreme that they may require careful medical preparation before any surgical procedure can be carried out. All cases of severe hyperthyroidism, when suffering from edema, dilatation of the heart, diarrhea, vomiting, etc., should be under observation a considerable period to improve their condition if possible. Frequently patients who at first appear to be very unfavorable subjects will improve so much under symptomatic treatment, aided by rest, hygiene, and the *x*-rays, as to become fairly safe surgical risks. In these extreme cases of hyperthyroidism, Porter recommends the injection of boiling water directly into the thyroid gland as being an efficient method of preparing them for operation. The writer has recently used the boiling water with satisfactory results.

Technic of Injection.—An all-glass syringe of 10 to 20 c.c., supplied with a rather fine long flexible needle, should be used. A filled syringe, together with the attached needle, is boiled over a gas or alcohol flame near the bed or table. The area to be injected is first infiltrated with 0.5 per cent. novocain. The filled syringe, which is actually boiling, is taken from the basin and the injection quickly made. From 5 to 20 c.c. of the boiling water are injected, according to the size of the gland. The injection should be repeated every few days until the desired effect is obtained. Porter[1] writes: "As to the relative efficiency of the boiling water injection and ligation of the vessels there seems to be no longer any reason for doubt. An injection of boiling water will accomplish more than a double ligation of the thyroid vessels, and also one can accomplish as much by one injection as can be accomplished by six weeks to three months of rest treatment. The relief following the injection usually manifests itself within the first twenty-four to forty-eight hours, and some patients show decided improvement in the symptoms of tachycardia and tremor immediately. The result of the injection depends upon the quantity injected and the kind of goiter one is dealing with. Hyperplastic thyroids of pure type, whether the hyperplasia is diffuse or circumscribed, respond most certainly." C. H.

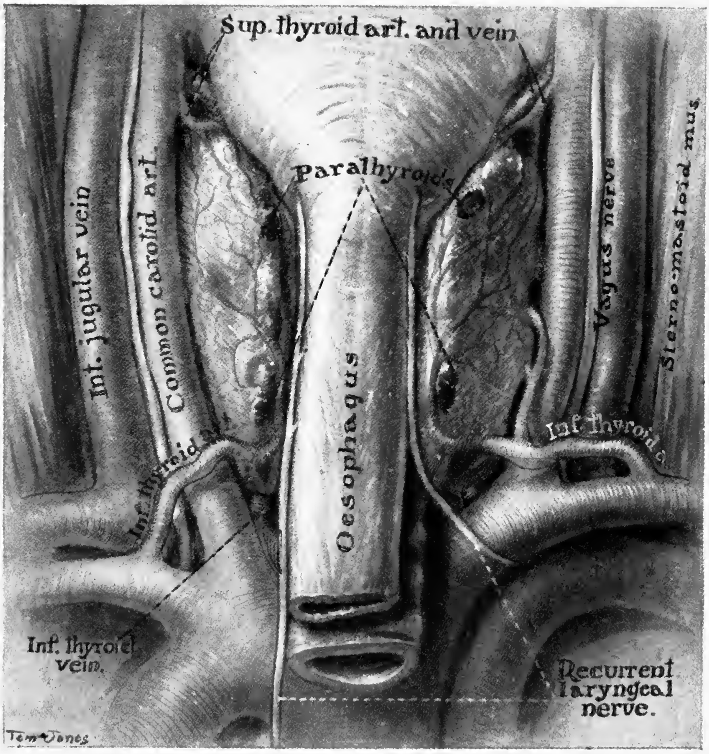
[1] Surg., Gynec. and Obst., January, 1915.

Mayo[1] says: "Extreme conditions, especially dilatation of the heart, may require medical preparation, and the operative interference following in cases resistant to treatment should be confined to the injection of boiling water into the gland after Porter's plan, to hasten improvement." Of the operative procedures for the relief of exophthalmic goiter, that of partial thyroidectomy is the operation of choice. There are a certain number of cases, however, in which it seems that the risk of radical operation of thyroidectomy is too great even after the most careful preliminary management. In such cases the ligation of the superior thyroid vessels on one side or both, as a preliminary measure to thyroidectomy, is frequently beneficial. Occasionally it is a difficult matter to decide upon just what procedure is advisable in each individual case. Many factors have to be taken into consideration in deciding as to what the patient may have done, with reasonable safety. The degree of intoxication the cardiac symptoms, especially in reference to the amount of dilatation, together with the mental stability, has to be taken into account. The severity of tachycardia is not of so much importance in determining what the patient is able to undergo as is the amount of dilatation of the heart and the degree of mental involvement. In general, one may say that whenever there is a dilatation of the heart of more than one inch to the left the risk of thyroidectomy is extremely great. In this class of patients a preliminary ligation of the superior thyroid vessels on one or both sides may reduce the production and absorption of thyroid poison to such an extent that the patient's general condition improves sufficiently to make it safe to perform the more extensive operation of thyroidectomy a few weeks later. Many of these extreme cases will improve greatly following the ligation of vessels, and in the past this operation was all that was deemed necessary in a certain group of cases. It has been the writer's experience that the patients treated by simple ligation have been very prone to suffer a recurrence of their symptoms, consequently this procedure should be used only in severe cases as a preliminary measure to the operation of partial thyroidectomy. In the majority of cases the proper operative procedure can be determined without difficulty. On the other hand there are cases in which this cannot be determined definitely until after the patient is brought to the operating room. Occasionally, on the day of the operation, there is found to have been an acute exacerbation of symptoms over the preceding day, so that the contemplated surgical procedure cannot safely be carried out. Crile[2] in trying to prevent such phenomena from occurring at this time endeavors to perform the operation without the knowledge of the patient. The experience of other surgeons, however, is that the performing of surreptitious operations is apparently unnecessary.

Exophthalmic goiter patients, however, require special consideration from the time they enter the hospital until after the operation is per-

[1] Collected Papers, 1913, p. 567.
[2] Kocher: Keen's Surgery. iii, 365.

PLATE XV



Posterior View of the Thyroid Gland.

Showing its capsule and bloodvessels and the relations to the parathyroid bodies and recurrent laryngeal nerves. An anomalous artery to the center of the right lobe is shown.

formed. In the first place it is necessary for the surgeon to have the complete confidence of the patient; second, it is important that all nurses and attendants should understand that owing to the disturbed condition of the nervous systems of these cases they are likely to become excited over trivial things, consequently extreme care must be used, so that nothing can occur which might possibly annoy them or excite any fear. The writer has found that by proper coöperation of all the attendants and by the administration hypodermically of $\frac{1}{4}$ grain morphin with $\frac{1}{100}$ grain atropin even these extreme cases will come to the operating room with no exacerbation of symptoms over the preceding day.

In almost all cases which come to the operating room with a pulse-rate of 120 or over there will be a reduction of from 10 to 40 beats per minute during the time the patient is undergoing the operation if the anesthetic is administered according to the method described above.

Ligation.—There is no doubt but that in the questionable and more severe cases the preliminary ligation of vessels is of value. The operation is performed in the following manner: These operations are best performed under local anesthesia, which is accomplished by infiltrating the tissues with 0.5 per cent. novocain solution, to which has been added a small amount of adrenalin chloride solution. The subcutaneous tissues, as well as the skin, should be infiltrated. Novocain is non-toxic and 0.5 per cent. solution can be used very freely, resulting in the advantage that a wide infiltration of the operative field, with liberal nerve blocking, can be effected. After the operative field has been anesthetized an incision is begun at about the middle of the thyroid cartilage and extended outward a distance of about one and a half inches, following one of the natural lines of the neck if possible. The incision is carried down through the skin, superficial fascia and platysma muscle. Retractors are now placed, separating these structures in the direction of the long axis of the body. The anterior border of the sternocleidomastoid muscle is now exposed and is retracted outward. The superior thyroid vessels are now exposed by dissecting free the anterior belly of the omohyoid muscle and retracting it upward and inward. By means of a ligature carrier a linen or silk ligature is passed around the thyroid vessels close to or including the upper pole of the gland. There need be no fear of injuring the nerve, as the ligation is made between the superior and the inferior larnygeal nerves. The wound is closed without drainage. If after one side has been ligated the patient's condition is good a ligation of the superior vessels may be made on the opposite side at the same sitting. In the extreme cases it is safer to make only a single ligation and note the reaction. If not much reaction follows it is usually safe to do a thyroidectomy a week or two following. On the other hand if much reaction follows the single ligation it is better to make a ligation of the opposite side one week later and delay the thyroidectomy for several weeks. Ligation of the inferior thyroid vessels is difficult and cannot be accomplished safely without first elevating the goiter. It is therefore not a practical procedure, because the risk is practically as great as when combined with immediate excision.

In extreme cases even the operation of simple ligation of the superior thyroid vessels on one side is not without considerable danger. The postoperative treatment is important. These patients must have absolute quiet and should be kept in a semisitting posture, be given water per rectum by the continuous drop method, or if this is not retained well, normal salt solution should be administered by hypodermoclysis. Morphin and bromides may be used to advantage and occasionally some of the preparations of strophanthus. The most important of these measures, however, are physical, mental and emotional rest and the large quantities of water. Quite marked improvement is reasonably certain to follow ligation, which is evidenced by signs of lessened toxemia in every way. In double ligation the height

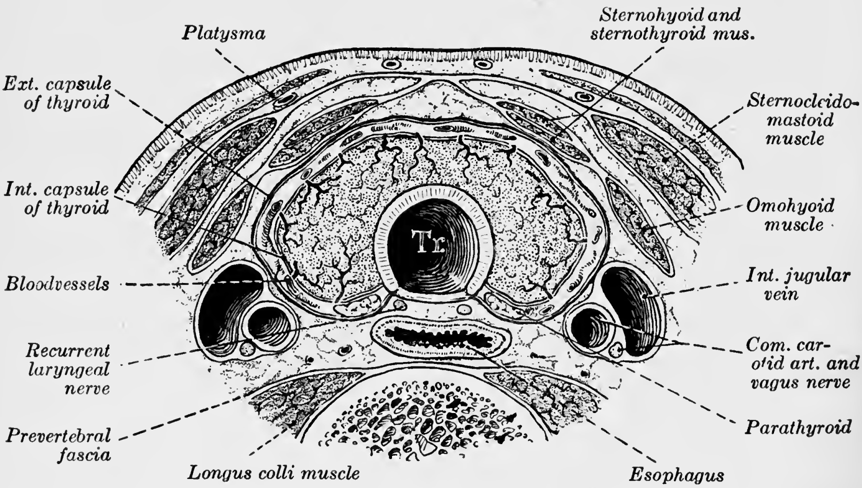


FIG. 557.—Transverse section through the thyroid gland. (After Corning.)

of improvement is usually reached in from twelve to sixteen weeks, at which time the operation of thyroidectomy may be done with comparative safety. During this period following the ligation of the thyroid vessels the patient usually gains considerably in weight and assumes a more nearly normal appearance, loses much of her nervous irritability and feels that she has actually recovered from a serious illness.

THYROIDECTOMY.—*Incision.*—The incision should be made so as to give a free exposure of all the structures encountered during the operation and also result in little or no deformity after the wound is healed. Free access to the operative field is important in order that various important structures can be protected during the operation and the loss of blood and traumatism be reduced to a minimum.

As all the muscles of the neck are arranged in pairs it is plain that in order to avoid deformity from the scar the incision must be symmetrical. The best incision to accomplish these conditions is the one introduced by Kocher, and called by him "the collar incision," as shown in Fig. 559. The incision, which is carried down through the skin and platysma, begins at one external jugular vein, following a gradual curve downward across the neck and up to a corresponding point on the opposite side, its center being about 3 cm. above the

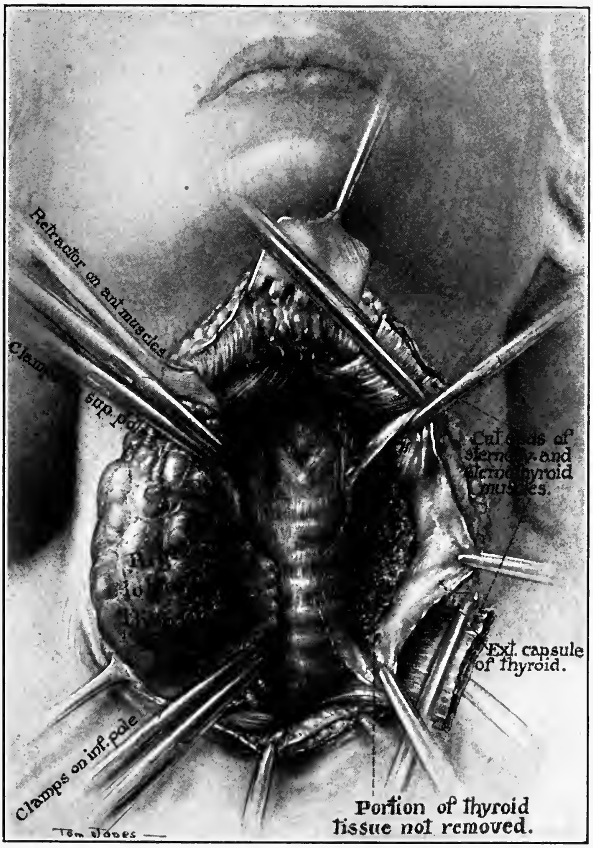


Fig. 558.—Left lobe removed, showing remaining thyroid tissue protecting posterior part of its capsule. Forceps placed upon upper and lower poles of right lobe.

upper margin of the sternum. The skin and platysma are dissected upward, exposing the sternohyoid muscles. In making this dissection care should be used not to injure the anterior jugular vein and numerous smaller veins, all of which are often quite large. By a vertical incision between the two anterior jugular veins the sternohyoid and sternothyroid muscles are separated. This incision should include the external fibrous capsule over the gland. Lateral traction is made on either side by retractors, drawing outward the sternohyoid and sternothyroid muscles, making a complete exposure of the goiter. In most simple goiters and also in some exophthalmic goiters the goiter can be removed easily through this exposure without cutting any of the muscles. In many large goiters and in most exophthalmic goiters this does not afford sufficient space for easy removal. In such cases it is necessary to cut off the sternohyoid muscles before proceeding further with the operation. The section of these muscles is made as high up as possible, so that when reunited the nerve supply has been preserved and the muscles and cutaneous scars separated, preventing a muscle-drawn scar, which moves up and down during deglutition. Two hemostatic forceps are placed across the sternohyoid and sternothyroid muscles

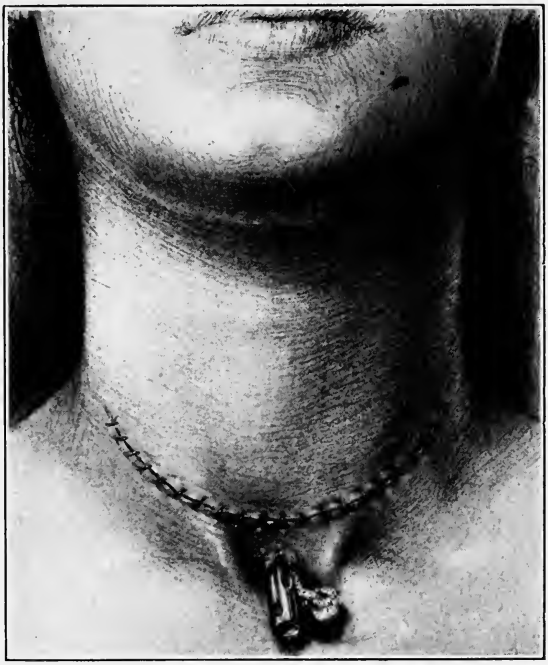


FIG. 559.—Showing the incision closed with horsehair sutures. A Kocher glass tube and a piece of formaline gauze are pressed through the puncture wounds as drains.

high up, but locked loosely so as not to crush the muscles. The forceps should be placed about 1 cm. distant from each other, so that when the muscles are cut between them they will not slip from the forceps. By gently passing the finger between the thyroid gland and the surrounding structures it is easily separated except for its posterior attachments. While the gland is rolled forward by gently raising with the hand and kept at slight tension, the lateral veins, which can be readily seen, are caught with two pairs of forceps and divided between. The superior thyroid vessels are now caught between forceps, which also grasp the corner of the upper pole of the gland. Three forceps should be used in order to avoid slipping, two placed proximal and one distal to the point where the vessels are to be severed. The anastomosing vessels from the isthmus are caught in the same manner. While the gland is still held in this position, three forceps are applied to the lower pole of the gland, grasping the inferior vessels in the same manner as the superior. Care should be used in placing the forceps well forward to avoid injury of the nerve which crosses the inferior vessels just below the lower pole of the gland posteriorly. By grasping a small portion of the lower pole in these forceps, being sure to keep in front of its posterior capsule, the nerve cannot be injured. It is not uncommon to encounter an artery of considerable size entering the gland near its center posteriorly. This is usually a branch of the inferior thyroid artery called the middle thyroid. In a number of cases there is still another artery, the arteria thyreoidea ima, usually only on one side. It is a direct branch of the innominate artery and runs to the thyroid isthmus. These, if present, are caught and ligated between the isthmus and the gland, near its upper and lower poles, and should be caught between clamps and cut. An incision is now made through the thyroid capsule along its lateral border and forceps are applied along the edge of the capsule posteriorly. The gland is now dissected forward toward the trachea, leaving the posterior capsule of the thyroid in its normal position in the neck, thus ensuring protection to both the nerve and the parathyroid glands. As the dissection is made, any small vessels encountered are clamped. If more than one lobe is involved it may be necessary to remove the isthmus, together with one lobe, or both the isthmus and a portion of the remaining lobe. To accomplish this the first lobe as it is dissected from the posterior capsule and rolled inward across the trachea is left attached to the isthmus while this part of the dissection is made. In making the dissection of the isthmus one must be careful not to injure the trachea, which is exposed at this point. In advanced cases, or in patients who have very hard nodules pressing upon the trachea, some of the tracheal rings may have been softened, so that when the isthmus is removed there is not enough support for the softened trachea, and the latter collapses during each inspiration, causing sudden asphyxia. An incubation tube or tracheotomy tube should be at hand, so that if necessary the asphyxia can be relieved at once. Fortunately, this accident does not often happen. A resection of the remaining lobe is accomplished in the same manner as described, except that after the inferior and lateral vessels have been clamped and severed as in complete removal of the first lobe, the branches of the superior vessels are grasped on the surface of the gland, together with the capsule at the point where the section of the gland is to be made. Considerable oozing takes place from the cut surface where section has been made. This is best controlled by whipping together the cut end of the gland by means of a catgut suture. More blood is liable to be lost during the resection of a lobe than from complete removal, for in the latter practically all the vessels can be clamped before they are severed.

The amount of thyroid tissue to be left varies according to the type of goiter. The more toxic the case the smaller the amount of thyroid tissue that need be left. In general the preservation of a portion of thyroid tissue in simple goiter equal to one-half the normal gland, and in exophthalmic goiter equal to one-sixth or one-fourth will probably be sufficient to prevent myxedema. In simple goiters only a few forceps are required, or practically all the hemorrhage is controlled by the application of the few forceps described above.

The technical difficulties in removing exophthalmic goiter are usually much greater than in simple goiter, because of the fact that in these cases the gland is very vascular and friable and its capsule is adherent. The bloodvessels are very numerous and their walls brittle, making it necessary to be very gentle in catching and ligating them. While only a few forceps are necessary in removal of a simple goiter, many dozen may be required in some exophthalmic cases. Care should be used in placing ligatures securely, especially those applied to the superior and inferior poles of the gland, so that there will be no danger of their slipping off during coughing or struggling while the patient is recovering from the anesthetic. It is important that the loss of blood during the operation be reduced to the minimum, and especially important at the close of the operation to see that all oozing surfaces are controlled, leaving the wound as dry as possible. Kocher believes there is a certain amount of specific toxicity in the blood in these cases, which if left in contact with the wound surface can be absorbed. producing acute toxic symptoms.

Drainage.—Efficient drainage, especially in exophthalmic goiter. is necessary in order to prevent absorption of blood or thyroid secretion from the wound surfaces. The method used should be one that will ensure immediate drainage at all times. For this purpose we have found the drain used by Ochsner to be very efficient. It is a combined drain, composed of a layer of gauze loosely packed into the. wound area from which the thyroid has been removed, with the additional introduction of a small glass drainage tube, both of which are brought out of the neck through a small stab wound below the original incision, as shown in Fig. 559. Drainage is left in place forty-eight hours.

Closure of the Wound.—If it has been necessary to section the sternohyoid and sternothyroid muscles the cut ends should be united carefully with a running catgut suture. The separated sternohyoid and sternothyroid muscles on either side are now brought together in the midline by catgut sutures. The skin should be closed in a manner to leave the least scar. A satisfactory method consists of first placing several subcuticular fine catgut sutures along the line of incision at regular intervals, uniting the platysma muscles and the subcutaneous fascia. This will remove all tension from the skin proper, which is now approximated by placing horsehair sutures, drawn just tightly enough to secure accurate coaptation, but not to cause any cutting. If these sutures are applied loosely and are removed on the fifth day there will remain no marks from their use.

MALIGNANT GROWTH OF THE THYROID GLAND.

Carcinoma and sarcoma may both occur in the thyroid, the former being much more common than the latter. Unfortunately, both of them are usually hopeless so far as treatment is concerned, because they are usually far advanced when the diagnosis is made. Occasionally, in thyroids which have been removed for relief of simple goiter, the postoperative microscopic examination has revealed the presence of carcinoma, and some of these patients have remained free from recurrence, because the growth had not extended beyond the limits of the gland. An attempt should be made to make an early diagnosis in these cases.

Fig. 560.—Showing the healed incision after partial excision of a large goiter. This woman had symptoms of severe intoxication and was emaciated as one can see by the prominence of the clavicle. The drain wound is still red and shiny but after a time this all disappears.

Diagnosis.—The early diagnosis is based upon the history and local physical findings. The growth of a malignant goiter is irregular. While many simple goiters are irregular, in malignant goiter one or more nodules will grow out from the main mass and become more distinctly palpable. If any patient over thirty-five years of age who has had a goiter for several years notices that the gland is enlarging without any apparent cause, malignancy should be suspected. If this enlargement be irregular in outline and upon examination is found to be firmer than the rest of the gland, losing its elasticity, the diagnosis may be fairly certain. The bloodvessels over the region of the gland are found to be abnormally well developed, although there is not at all a characteristic sign. Displacement of the surrounding parts is irregular, because the growth often increases only on one side. On account of the irregular development and the early development of adhesions, slight pressure signs develop early, characterized by change in the voice, local signs of venous obstruction and slightly impaired mobility of the head or neck. A careful history will often elicit these signs early in the disease. All other symptoms, such as pain, dysphagia, cachexia and loss of weight, only occur later after the disease has advanced to a hopeless degree. Metastases occur comparatively early in the disease. Unfortunately, it is rarely possible to obtain a permanent cure in cases in which positive diagnosis of a malignant growth can be made before the operation.

FIG. 561.—Sarcoma of thyroid resembling in gross outline a large colloid goiter.

Treatment.—Early operation offers the only hope of relief in malignant condition, but, unfortunately, many of these conditions are not recognized until the patient has reached a hopeless condition. Operation is contra-indicated in the presence of metastases, and when the growth has perforated the capsule, making it so adherent to the surrounding structures as to render its complete removal impossible. Occasionally, treatment is required to relieve the terrible sufferings from dyspnea, with impending asphyxia. This, however, is often a difficult matter to do, because the operation of tracheotomy in the presence of a malignant goiter is one of the most difficult operations to accomplish. It is often impossible to do without first removing a portion of the goiter.

Malignant goiter usually involves only one lobe of the thyroid primarily, and if the diagnosis is made before the growth has invaded the capsule the immediate prognosis is scarcely more grave than in the operation for simple goiter. The operation should consist of complete incision of the entire thyroid with the capsule, even to the extent of endangering the parathyroids and nerve on the involved side. The author has one patient well ten years after removal of the thyroid for carcinoma, and two other patients are apparently well several months, one of these being a localized carcinoma in a substernal goiter from the lower pole of the left lobe of the thyroid. In this case there was a complete excision of the left lobe together with its capsule and parathyroids. The right lobe was not disturbed, as it appeared normal both in size and structure. This patient has exhibited no signs of tetany.

POSTOPERATIVE TREATMENT.

In advanced cases of hyperthyroidism much may depend upon the after-treatment. The patient should be placed in the semisitting posture, with an ice-bag over the precordial region. Immediately after the operation it is important to supply an abundance of liquid to the patient by giving hot water by mouth and the administration of normal saline solution per rectum by the continuous drop method. In the majority of cases, liquids administered in this manner will be sufficient, but if the patient exhibits signs of postoperative hyperthyroidism, 1000 c.c. of salt solution should be administered by hypodermoclysis and repeated every eight hours until the symptoms subside.

Ochsner has recently recommended repeated gastric lavages as an important aid in lessening the postoperative toxicity in severe exophthalmic cases. He has found repeatedly that patients with extreme symptoms of hyperthyroidism would invariably be immediately improved by a gastric lavage. The author believes that by the combined use of repeated saline transfusion and gastric lavages a certain number of extreme cases can be gotten well that otherwise would result fatally. The use of opium in some form, combined with sodium bromide administered per rectum, is often a great aid in securing rest in the very restless cases.

After-treatment.—Owing to the fact that in the majority of patients suffering from toxic goiter for any considerable time a certain amount of permanent injury has occurred to vital organs, it is important to give these patients definite directions as to their habits and mode of living for an indefinite period. This is essential not only to reëstablish their health and strength, but also to maintain this after it has been established. While the majority of these patients recover sufficiently to be able to lead fairly comfortable, useful lives, they are not in a condition to compete with the average individual and indulge in physical, mental, emotional and dietetic excesses. We make it a rule to give all patients who have suffered from toxic goiter a printed list of instructions to follow for a definite time after they return to their homes, and emphasize thoroughly the fact that the permanency of their cure depends largely upon the care with which they carry out these directions. The directions briefly summarized are: Avoid overwork, excitement, alcohol, tobacco, tea and coffee, social and business worries and to select diet composed largely of milk, cooked vegetables, cereals and fruits.

SURGICAL IMPORTANCE OF THE PARATHYROIDS.

While our knowledge of the parathyroids is very meager, it is evident that these glands possess a function that is essential for the normal metabolism. Considerable animal experimentation has been done with the parathyroids, and one fact has been established, and that is, that removal of the parathyroids is followed by a condition termed experimental tetany.

Tetany following operation of thyroidectomy is undoubtedly due to removal or injury to the parathyroid tissue. It is important, therefore, that the surgeon use the utmost care to guard against removal or injury to these structures. Owing to the fact that they are situated behind the posterior capsule of the thyroid gland, their injury is not likely if one remains in front of the capsule during the dissection or removal of the thyroid. The surgeon should, however, bear in mind the size and appearance of the parathyroids, and if any small gland-like masses about the capsule should have been accidentally removed during the operation, they should be implanted at some point back of the capsule of the thyroid.

At the present time there is no reliable treatment for tetany. Assuming that the condition is due to deficient parathyroidal tissue, the treatment indicated would be an attempt to make up the deficiency by transplanting parathyroids from other persons, the use of serum or the extract of parathyroid, and the administration of calcium salts to restore the balance in calcium metabolism. All of these measures have been used, but, unfortunately, have not given uniformly satisfactory results.

In two cases of tetany following thyroidectomy we have administered 10 grains of calcium lactate every hour for a few days, then every two and later every three hours, then four times each day for two months. Both of these cases recovered fully, but it is difficult to say whether this was a coincidence or whether the recovery was due to the remedy. In both cases the contractions of the muscles ceased shortly after beginning the administration of the remedy and commenced again when the remedy was temporarily abandoned, only to disappear again when the remedy was again administered.

THE DUCTLESS GLANDS.

By GEORGE W. CRILE, M.D., F.A.C.S.

Research and clinical experience are rapidly accumulating evidence that the interaction of the ductless glands by means of their secretions or hormones has a vital bearing upon the welfare of the organism and that these secretions play an important role in certain pathologic conditions. The preëminent example of such a far-reaching organic effect is presented by the role of the thyroid in exophthalmic goiter; while the interaction of the different glands is well exemplified by the increased activity of the adrenals in the same disease, in which the increased adrenal secretion in turn probably increases the thyroid activity.

Surgery has defined the relation of the thyroid to exophthalmic goiter and as a result has established the operative treatment for exophthalmic goiter as securely as the operative treatment of diseases of the gall-bladder or of the pelvic organs. In the light which has thus been thrown upon this disease it is apparent that every part of the organism is affected, and a resultant profound alteration in metabolism produced.

The drive in exophthalmic goiter could scarcely have been initiated by the thyroid. It would seem rather that the thyroid is driven by other forces; for example by the nervous system directly through the innervation of the thyroid cells, and the innervation of the bloodvessels of the thyroid. According to Cannon the thyroid is stimulated by adrenalin. It seems doubtful whether exophthalmic goiter could originate under conditions of subnormal impulses or in the presence of a subnormal amount of adrenalin. With this view of the thyroid and the adrenals as two demonstrable interactive links in the kinetic system, we shall in the main confine our discussion to a consideration of the specific role of each.

THE THYROID.

The chief role of the thyroid seems to be that of increasing the metabolism of various organs and tissues. It does not appear that the thyroid specifically influences the function of any one organ more than another. There is no evidence that the thyroid influences in any degree the procreative, the physical self-defensive, or the chemical self-defensive mechanisms as such—but it intensifies their respective actions when these mechanisms are integrated for increased activity.

If the thyroid has no selective influence upon any specific organ how can we explain the fact that in myxedema there is diminished sexual excitation, and conception does not occur? First of all, it should be remembered that animals whose ovaries have been removed early in life have no sexual desires. Male animals which have been castrated in early life have no sexual desire. From these facts we may infer, at least as far as sexual life is concerned, that the generative organs receive the sex stimulus, and these organs in turn indirectly excite the thyroid to activity. The resultant secondary thyroid stimulation increases oxidation.

HYPERPLASIA OF THE THYROID—GOITER.

How is the thyroid enlargement so frequently seen in adolescence to be interpreted? The secondary sexual characters will not develop unless the sex organs are developed, and neither will they develop in the absence of the thyroid. The loss of the sex organs prevents sex differentiation only; the loss of the thyroid prevents all development impartially. We conclude, therefore, that the thyroid influence is an essential basis upon which sex differentiation depends. For this reason, during the period of active sex differentiation, the thyroid is called upon to increase its activity. We may suppose that when the normal thyroid gland is unable to meet the increased demands made upon it in the period of adolescent development it undergoes hyperplasia.

If iodin is given during this period hyperplasia will not result. Moreover, Marine has shown that if iodin or thyroid extract be given over a sufficient period the hyperplasia reverts to the colloid type.

It is not only during adolescence or as the result of sexual activation that the thyroid enlarges. It not infrequently enlarges in the presence of infection. As the mechanism of the production of fever requires increased oxidation, the thyroid is driven to greater activity, and hyperplasia may result according to the ability of the gland to meet the additional demands upon it. In these cases also if iodin be given, hyperplasia will not result.

In like manner we may suppose the constant stimulation of the thyroid from the absorption of toxins from the intestines causes hyperactivation of the thyroid with the resultant tendency to hyperplasia. Since, as we have indicated above, the participation of the thyroid in the response to infection, to sex stimulation, to auto-intoxication is secondary, through the nervous system which received the primary activation, the secondary participation of the thyroid through the nervous system in the activation produced by fear, by anger, by worry, by overwork, and the resultant hyperplasia, is understood.

As stated above, hyperplasia of the thyroid may be produced by any of the factors that sufficiently activate the kinetic system. This hyperplasia may subside when the cause is removed and the gland reverts to its normal state or the gland may remain permanently enlarged—thus gradually building up a goiter.

ADENOMATA—THYREOTOXICOSIS.

The symptoms produced by adenomatous glands are identical with the phenomena of overactivation of the kinetic system from other causes. There is increased metabolism; increased circulation, increased respiration; there is a tendency to the production of fever. When the organism is rendered hyperactive by an adenoma, any other activation —such as emotion, exertion, infection, causes an abnormal response. The activity of the heat elimination mechanism is increased, as is indicated by the increased circulation in the skin and the increased activity of the sweat glands. The activity of the brain is increased and its thresholds are low. Energy is discharged with the increased facility characteristic of the hyperdynamic state. The entire kinetic system shows the organic changes characteristic of overwork—the liver is enlarged, its cells are degenerated; the muscular system shows degeneration; the adrenals are sometimes hypertrophied; there is a tendency to glycosuria; the kidneys show a tendency to nephritis, the myocardium may become degenerated; the brain cells are exhausted. The whole organism has been impartially driven by the thyroid cells of the adenoma. The symptoms are identical with those produced by overfeeding with thyroid extract or by iodin or by overwork of any kind. What has caused this body-wide effect? Conclusive evidence that it is due to a pathologically altered secretion is wanting.

Indeed, it would appear that the designation of this abnormal thyroid stimulation as thyreotoxicosis does not correctly express the disease. It would be as fitting to designate the kinetic phenomena of a breakdown from excessive athletic strain as "athletic-toxicosis," or the damaging kinetic action of excessive emotion as "emotio-toxicosis."

A possible clue to the body-wide action of the active adenomata may develop from the finding in our laboratory studies of the electric conductivity of normal and pathological tissues, namely, that the conductivity of some of the adenomata measured was higher than the conductivity of any other tissue studied.

MYXEDEMA.

In the preceding sections we have considered the effect on the body of an increased activity of the thyroid. What are the effects of diminished thyroid activity? When the thyroid secretion is diminished below the needs of the organism we find antithetical phenomena to those produced by the hyperactive gland—diminished muscular power, diminished mental power, diminished consumption of energy-producing compounds, decreased intake of food energy, increase of stored energy in the form of fat, much swelling of subcutaneous tissue. The low ebb of kinetic activity is evidenced by the low temperature, the mild reaction to infection, to trauma, to environmental stimuli which in the normal individual would excite fear or anger. The individual becomes adynamic, stupid, heavy. There are frequently pains in the joints with some thickening of the joint surfaces and margins. All these phenomena are as obviously phenomena of diminished oxidation as those of hypersecretion are phenomena of increased oxidation.

These phenomena are peculiar to the developed adult with diminished thyroid activity.

There is also a congenital thyroid deficiency—cretinism—which occurs chiefly in goiterous districts. The cretin develops slowly, both mentally and physically, and at twenty may be no more mature than a child of eight. Not only is there lack of physical and mental development, but sex differentiation does not occur—the cretin is in effect a neuter.

If thyroid feeding be initiated at an early date, the cretin may be transformed into a normal individual. Bodily growth will be promoted, mental development awakened, the secondary sexual characteristics will be established, and as a final proof of the efficiency of the normal production of the thyroid gland, the congenital cretin may be so transformed by the administration of thyroid extract as to become fertile.

EXOPHTHALMIC GOITER—GRAVES'S DISEASE.

With two exceptions the phenomena of exophthalmic goiter—Graves's disease—are identical with those which accompany activation of the kinetic system by any other cause, whether fear, anger, sexual excitation, athletic contests, acute overwork, acute infection, or the presence of an adenoma. The two exceptions are the *invariable* presence of thyroid enlargement in Graves's disease, and the fact that in Graves's disease the activation is continuous and is not interrupted by sleep, which is true of infection also. Even the pathology of Graves's disease is characteristic of each of the other forms of kinetic activation. Moreover with but two exceptions the phenomena of Graves's disease are identical with those of hyperactivation from adenomata, the exceptions being the presence in Graves's disease of thyroid hyperplasia, and of the emotional facies with exophthalmos.

Another distinction may be added: In exophthalmic goiter the pathologic activation may be broken at any of the links in the kinetic chain; the drive of the hyperkinetic adenoma can be controlled only by the removal of the adenoma.

The identity of the phenomena of kinetic activation with exophthalmic goiter is especially exemplified by the difficulty in differentiating between exophthalmic goiter and the infections. Clinicians of wide experience at times mistake latent tuberculosis for Graves's disease, and Graves's disease for latent tuberculosis. The author recalls that in one instance one of the best diagnosticians he has ever known mistook an advanced case of Graves's disease for chronic tuberculous meningitis. Tachycardia, increased respiration, flushed face, tremors, slight fever, no cough, nervousness, anxious facies, rapid loss of weight are alike signs of tuberculosis and of Graves's disease in the stages before the distinguishing physical signs of either are marked.

Differentiation between Exophthalmic Goiter and Thyreotoxicosis.—As noted above, the hyperplastic gland in Graves's disease is associated with exophthalmos and emotional facies. Adenoma toxemia shows neither of these phenomena. There is a distinct difference in the clinical symptoms also—Graves's disease runs a far more irregular, more dynamic course. In Graves's disease the thyroid output is largely under the control of the nervous system, and in consequence it is largely governed by environmental stimuli. Environment influences the output from the adenomatous gland but slightly if at all.

The adenoma toxicosis therefore runs a chronic, more even course as compared with the acute uneven course of Graves's disease. Excision of the adenomatous gland is safer than of the hyperplastic type; and the clinical end-results of the former are better, probably because of the lack of nervous involvement. Ligation of the superior thyroid arteries exerts less influence on cases of adenoma-thyreotoxicosis than on cases of exophthalmic goiter. This difference may well be due to the fact that the cases of pure Graves's disease are more completely under the influence of the nerve supply of the thyroid. In ligation the nerve supply is broken.

The Mechanism of Exophthalmic Goiter.—Iodin increases the electric conductance of living tissue; iodin increases permeability; increase in permeability increases function. It is apparent that the thyroid gives off its iodized protein adaptively in exertion, in emotion, in infection, in procreation, etc.

Ashoff and others state that stimulation of the nerve supply of the thyroid causes a discharge of iodin; hence, we may suppose that the output of iodin is in part at least under the control of the nervous system. In exophthalmic goiter, there is marked nervous activity and we may suppose that the thyroid is under active stimulation; that this is the case is shown by the low iodin content of the gland in exophthalmic goiter. Cannon states that adrenalin activates the thyroid. We assume that the activated thyroid throws out large amounts of activating iodin which by so much facilitates permeability; hence, increases activity of the body, including the activity of the thyroid itself and of the adrenals. Oxidation is the basic process in metabolism; adrenalin increases oxidation; iodin increases electric conductance, hence increases metabolism.

Therefore, through the mediation of the nervous system, a reciprocal interaction is established among the thyroid, the adrenals and the nervous system. Iodin alone, adrenalin alone, thyroid extract alone, emotion, or exertion, or infection alone, each causes a "Kinetic Drive" with phenomena similar to those of exophthalmic goiter.

If the foregoing interpretation be correct, then the drive of exophthalmic goiter should be diminished by lessening the activity of any one of the three interacting organs—of the brain, by rest cure; of the thyroid, by its resection; of the adrenals, by the removal of a portion of its tissue, though evidence of the positive value of the last-named procedure is thus far incomplete.

Nothing in surgery is more striking than the immediate benefit of surgical treatment of exophthalmic goiter, as evidenced by the results of 2180 partial thyroidectomies performed by the author, of which 1148 were for exophthalmic goiter.

It is of interest to note that the active principle of thyroid secretion has been synthetically produced by Kendall; adrenalin is synthetically made; and electricity is everywhere fabricated; hence, the equivalents of the activators of exophthalmic goiter, of emotion, of exertion, and of fever may be made in the laboratory.

Among the results often noted after thyroidectomy are:

(*a*) A decrease in the systolic pressure and less frequently a decrease in the diastolic pressure.

(*b*) Diminished nervousness.

(*c*) Diminished myocarditis.

(*d*) General restoration of the widespread impairment due to the excessive speeding of the kinetic system.

In a case thus relieved, an overdose of thyroid extract will reëstablish the symptoms. The postoperative state of serenity of the exophthalmic goiter patient is comparable to the colorless state after one has passed through a great emotion.

The Mechanism of the Infections in their Relation to the Thyroid Gland.—That the thyroid is involved in the response to infection is shown by the following facts:

In cases of excessive thyroid feeding and of exophthalmic goiter there is an increased metabolism, and infections cause abnormally high temperatures.

In myxedema the body temperature is subnormal, and though myxedematous subjects succumb to infections, they show little febrile reaction.

As stated above the specific action of the thyroid is due to its specialized iodin. There is strong evidence that the brain drives the organism by means of electric energy. Iodin causes an increase in electric conductance, therefore the effective work of the electric energy theoretically created by the cells of the nervous system would be correspondingly increased by the iodin facilitation.

Iodin alone causes all the symptoms of an infection. It is almost impossible to differentiate between an acute infection and acute iodoform poisoning.

After operations for exophthalmic goiter, who can distinguish with accuracy between the febrile reaction facilitated by the activation of the organism by the hyperactive thyroid and the activation due to an acute infection?

In chronic infections, and even in prolonged acute infections such as tuberculosis, the thyroid is hyperplastic. Thyroid enlargement is frequently demonstrable during an acute infection. Acute tonsillitis may cause the thyroid to enlarge and to remain enlarged.

After the removal of infected tonsils the thyroid sometimes subsides promptly.

In the acute infections, even in the chronic infections, the individual is palpably under the influence of the thyroid. One of the evidences of this is the nervous state of the patient, which is but an indication that the nerve pathways have been facilitated by iodin for the more ready passage of the electric driving force.

All the experimental and clinical evidence indicates that a large role is played by the thyroid in the defense of the organism against the infections.

The Mechanism of Nervousness in the Infections in its Relation to the Thyroid Gland.—The evidence of the participation of the thyroid may with equal logic be applied to the obvious mechanism of nervousness.

In exophthalmic goiter cases the nervousness is similar to that of infections—the restlessness, the tossing and the sleeplessness may be regarded as phenomena of the facilitation of the electric conductance by iodin.

On the next day after a lobectomy has been performed in an exquisitely nervous, excitable, exophthalmic goiter patient, the one conspicuous change—conspicuous to the nurse, but of infinite comfort to the patient—is the loss of the intolerable restlessness, intolerable excitability. We may conclude, therefore, that the nervousness in fever is due to the increased action of the thyroid. Do myxedema patients show an equal increase of nervousness in infections?

The Treatment of Exophthalmic Goiter.—In advanced exophthalmic goiter the internal respiration is abnormally sensitive, as indicated by the adrenalin test (Goetsch), by the baneful effect of diminished exchange of air from obstruction to the trachea, or from any interference with the internal respiration, as in deep anesthesia, and by the ill effect of increased internal respiration from emotion or from injury. The operative procedure therefore should be graded according to the severity of the disease.

The anesthetic should be nitrous oxide, which, as a rule, should be administered in bed, the patient being transferred to the operating room after anesthesia is established.

In moderate cases the entire operation may be completed in one seance. In more severe cases the thyroid activity should be diminished by a preliminary ligation in bed, under nitrous oxide analgesia and local anesthesia.

In extremely grave cases it may be necessary to diminish the thyroid activity by multiple steps, ligation of one vessel, ligation of the second vessel, partial lobectomy, complete lobectomy, allowing intervals of a month or more between these successive stages. If during operation the pulse runs up beyond the safety-point, it is advisable to stop the operation and dress the wound with flavin, completing the operation after a day or two when conditions are safe. In some cases, though the thyroid is resected, it is advisable to dress the unsutured wound with flavin and make a delayed closure in bed the following day under analgesia. In certain cases lobectomy is performed in bed under nitrous oxide analgesia and local anesthesia.

In multiple stage operations the length of the interoperative intervals is determined by the degree of physiological adjustment.

Psychic control is required throughout to diminish the intense drive by establishing confidence and hope. An anociated regimen should be prescribed for the preoperative, interoperative and postoperative periods.

If after operation there is inaugurated an excessively high temperature, with greatly increased pulse and respiration, then on the principle that heat increases chemical activity and electric conductivity, and that these in turn increase heat—such patients are literally packed in ice—packed early. This procedure has been found to exercise a remarkable control over the destroying metabolism.

This postoperative phase of exophthalmic goiter is closely analogous to heatstroke in symptoms and in control; and both heatstroke and the so-called postoperative hyperthyroidism are the antithesis of shock in which by contrast the mechanism for the fabrication of heat is paralyzed. In the latter, heat is as useful as cold is in the former. The treatment for each is planned in accordance with the simple laws of physics. The practicability of the plan of treatment outlined above has made possible in the Lakeside Clinic the following record: 206 consecutive thyroidectomies, of which 72 were of the exophthalmic type without a death; 100 ligations without a death. No case is rejected for operation.

THE ADRENALS.

In the preceding sections we have referred to the interaction of the thyroid with other component parts of the kinetic system, particularly the adrenals. In addition to this interaction between the thyroid and the adrenals the effects of the secretion of the glands are identical, for adrenalin alone, as Cannon has shown, like thyroid secretion, causes all the basic phenomena of exertion, of emotion, of infection, of autointoxication, etc.

The interaction of these glands and their specific function in the kinetic system may be briefly expressed as follows: The thyroid gland has been evolved to hoard iodin (Marine). Iodin facilitates oxidation —metabolism. Oxidation is markedly controlled by adrenalin. In their capacity to promote metabolism upon which vital processes depend the adrenals and the thyroid may be considered the activators of the kinetic system. Although the action and the end-effects of the secretion of the adrenals and of the thyroid are identical in many respects, an important distinction in the action of these organs should be noted. The action of adrenalin is immediate and evanescent; the action of thyroid secretion is slower, but is persistent. It is the long pull, therefore, the protracted worry, the chronic infection, the prolonged activations of adolescence and of pregnancy that tax the thyroid. For the sudden discharge of energy in sudden anger, in a short intense struggle, in an acute infection of sudden onset, in an overwhelming emotional crisis, the adrenals supply the material to meet the unexpected demand for increased metabolism.

When there is adrenal deficiency the power of the body to fabricate heat and muscular or mental action is diminished or lost.

Electric Conductivity in its Relation to the Adrenals and the Thyroid.—A further clue to the function of the adrenals and of the thyroid as activators has been found in a line of research now in progress in our laboratory in which the electric conductivity of animal tissues has been studied under varying conditions, in particular those conditions whose phenomena, as we have stated above, are identical with those that follow the administration of adrenalin and of thyroid secretion, *i. e.*, intense short seances of exertion and of emotion, protracted seances of exertion and of emotion, the immediate and the late effects of physical injury (surgical shock), early and late infection, iodoform poisoning, pregnancy, etc. We found that sudden crises, such as a short intense seance of fright, the immediate reaction to an acute infection, physical injury, the injection of adrenalin caused an immediate increased conductivity of the brain, followed by a late decrease.

It is through the brain that the environmental stimulus is conveyed to the adrenals and to the thyroid. If activation of the brain and the response of the organism is a phenomenon of electric energy, as accumulating evidence leads us to believe, then since electric energy depends upon oxidation, and oxidation is influenced by adrenalin and by thyroid secretion, the role of the thyroid and of the adrenals as activators of the electrically operated mechanisms is further established.

It is not without interest to note, and perhaps it is significant, that convulsions frequently occur in the onset of acute infectious diseases in children, in which there is reason to believe there is a free output of adrenalin, a quick and powerful metabolic activation. This increased metabolic activity may be interpreted to mean an increased output of electricity, so great that the overdriven motor cortex in turn drives the organism to extensive muscular contractions—convulsions.

Moreover, if electricity is the driving force of the organism, and if electric power is increased by increasing the conductance of the tissues over which it passes, it would follow that there must be in the body an organ which can supply to the body a substance which can immediately increase electric conductance to meet sudden crises, and an organ which for periods of weeks and months can furnish a continuous supply of a substance which can accomplish the same purpose for protracted needs.

Adrenalin, as our conductivity studies would indicate, answers the first requirement. As to the second, Osterhout has shown that iodin increases electric conductivity in living tissues, and our studies, referred to above, of the effects upon electric conductivity of thyroid feeding and of iodoform poisoning indicate that the protracted needs of the electrochemical mechanism may be well met by the thyreo-iodin fabricated by the thyroid.

SURGERY OF THE THYMUS GLAND.

By A. J. OCHSNER, M.D.

There is no other important organ in the human body which has received so little surgical attention as the thymus gland.

1. The gland is inaccessible as compared to other structures, but this is a more apparent than real reason for the fact that surgeons have avoided interfering with this gland; because its removal is really quite simple, and except for the fact that patients in whom the operation is indicated are bad risks from their long-continued suffering, the operation would be relatively quite safe if performed according to the rules laid down by Kocher, Olivier, Crotti and Mayo.

2. The most important reason lies in the fact that practically the entire physiological existence of the thymus gland is confined to a period of the life of patients when they became the objects of surgical treatment only in case of serious acute disease, such as empyema, appendicitis and only conditions due to infection or trauma.

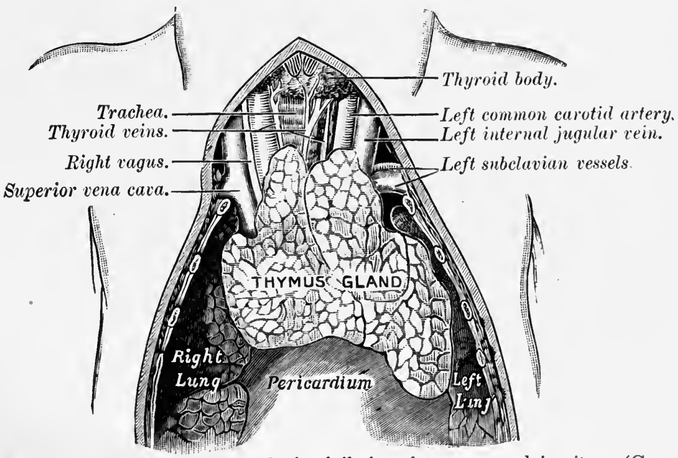


Fig. 562.—The thymus gland of a full-time fetus exposed *in situ*. (Gray.)

3. This gland from the time of the birth of the child has a tendency to eliminate itself from the organism, and consequently becomes rapidly less important as the patient becomes more and more important surgically. Its growth ceases under normal conditions about at the end of the twelfth year of age. Soon after this it begins to decrease, so that at the age of eighteen to twenty it is little more than a rudimentary remnant. At birth the gland, according to Hammar, should weigh about 13.26 grams; at its greatest development between the age of

eleven and fifteen years, 37.52 grams, or nearly three times the original weight; and at seventy-five years of age, only about one-half the weight at birth, or 6 grams.

4. The only surgical treatment which seems available consists in the removal of the gland, which seems a formidable operation for conditions which are supposed to be caused, entirely or partly, by abnormal action of the thymus gland.

5. It is, however, likely that a very important reason for the absence of thymus-gland surgery lies in the fact that our attention has not been directed to this organ, and, like many other organs which were overlooked surgically until recent years, careful observation and study and attention to this organ may uncover pathological conditions which will in the future class these in the list of surgical diseases for a time at least.

6. At the present time the condition which seems to attract most attention is hypertrophy of this gland in children, resulting in pressure upon the trachea, and persistence of the gland in adults at a time when the organ should have been eliminated by the natural course of trophic events in the development of the human body. In both instances the systematic application of properly regulated *x*-ray seems to suffice, in most cases, to relieve the condition safely and for promptly doing away with the necessity of surgical interference.

What has been accomplished surgically has been confined to the work of relatively few surgeons, whose activity in the surgery of the thyroid gland has attracted their attention especially to this organ, which is closely related to the former.

The position of the thymus gland places it in relation to so many important structures that a timid surgeon would scarcely feel inclined to attempt its removal.

It lies between the sternum and the trachea above and approaches the pericardium and large vessels below. Laterally lie the large vessels of the neck, the phrenic nerves and on the left side the gland touches the pneumogastric and the recurrent laryngeal nerves.

Obstruction to inspiration, due to pressure of the thymus gland upon the trachea, is characterized by cyanosis during inspiration and retraction of the contour of the neck, while during expiration there may be a bulging in this region.

The first thymectomy was performed by von Rehn in Frankfort in 1896, giving perfect relief in a case of obstruction to respiration, due to pressure caused by an enlarged thymus gland.

There seems to be an intimate relation between the thymus gland and the various organs of internal secretion, which has been borne out both by animal experimentation and clinical observation; but at the present time this relation has not as yet been definitely analyzed. It seems certain, however, that the most important function of this organ has to do with the trophic element in the development of the human body, and that when the adult growth has been reached the organ withdraws physiologically from its active participation in the influence upon any of the organs of the body except in so far as it seems to supplement some of the functions of the thyroid gland, probably to a slight degree.

The interrelation between the thyroid gland and the thymus seems to be confirmed by the fact that the tissues of the thymus gland become more active, as is shown by histological changes when the thyroid gland has been removed.

In goiter regions the newborn have an enlargement of the thymus gland in a large proportion of the cases examined at postmortem, although in only a small number of infants born with hyperplasia of the thymus is there any marked hypertrophy of the thyroid gland at the time of birth. On the other hand, in these regions the combination of goiter and hyperplasia of the thymus gland is very common in the adult.

Diagnosis.—There are two conditions which are most likely to cause the diagnostician to suspect hypertrophy of the thymus gland—namely, obstruction to respiration, which cannot be accounted for in any other way, and a condition characterized by general hyperplasia of the entire lymphatic system, tonsils and adenoids, and enlargement of the spleen, with a pale, sallow color of the patient and a lack of energy and resistance, a condition, called by Paltauf "status lymphaticus." This condition is most common in infancy.

J. F. Herrick[1] gives obstruction as one of the chief symptoms of hypertrophy of the thymus in infancy; the left lobe often being larger, causes greater pressure. The symptoms often simulate foreign bodies in the trachea.

He attributes some deaths to pressure upon the pneumogastric nerve, the great vessels and the auricle, counting this more important in many cases than pressure upon the trachea. Percussion and x-ray examination give the most positive indication of the size of the enlarged gland.

E. Olivier,[2] who prefers surgical treatment to x-ray, classifies thymus hypertrophy in three forms: (1) Continuous form with permanent dyspnea. (2) Intermittent form with suffocation crises. (3) Atypical form.

He classifies the symptoms as follows for Class I:

(*a*) Bad respiration from early age. Beginning of respiration easy; last half, difficult, the air having to be pushed out. Respiration worse at night.

(*b*) Permanent dyspnea.

(*c*) Rales and stridor on inspiration.

(*d*) Substernal median retraction increased by hyperextension of head and recumbent position.

(*e*) On expiration thymus appears in neck, disappears on inspiration behind manubrium.

(*f*) There may be bulging of sternum with dulness of percussion.

[1] Surg. Gynec. and Obst.

[2] De la valeur et des indications operatoire du thymus, Veau et Olivier, Jour. de Chir., 1912, p. 233.

He points out the importance of differentiating enlarged tracheobronchial glands following bronchopneumonia. The thymic tumor is less voluminous and less lobulated than glands. In this the x-ray and the previous history are most important. He gives as indications for operation the following three conditions: permanent dyspnea, stridor, suffocation. His statistics show twenty operations with eight deaths.

The non-surgical treatment consists in the careful use of x-ray treatment. J. F. Herrick reports several cases with ideal results in children. The method of treatment corresponds with that described in the chapter dealing with the therapeutic use of x-ray in this work.

It seems necessary, however, to regulate this treatment carefully according to Klose and Vogt.[1] These authors warn against the careless use of x-ray in these cases, because of the danger of destroying the entire gland, causing the production of rickets, retarded growth of the child, anemia, calcium elimination, etc.

Thymectomy.—Two facts must be borne in mind at all times during the progress of this operation: (1) the fact that the capsule of the gland is quite closely in contact with the large vessels mentioned above; (2) that in most instances a line of cleavage can be determined between the capsule of the gland and the surrounding tissues, or in cases of strong adhesions, the capsule can be left in place, the surgeon removing only the gland substance, which can usually be readily accomplished, especially if the operator's fingers are not covered with gloves. In case of injury to the wall of one of the veins the opening must be instantly closed with the end of the finger to prevent air embolism. The cavity of the capsule should then be carefully tamponed with gauze, as it is difficult to control hemorrhage because of the danger of injuring important structures. In most cases, however, the bleeding is very slight because at each step of the operation the tissues containing bloodvessels are carefully clamped, cut and ligated as the operation progresses, so that the wound can usually be closed.

The gland can be approached most conveniently through the transverse collar incision, which has been described frequently in connection with the operation of thyroidectomy. In fact the operation has been performed more frequently as an additional step at the conclusion of a thyroidectomy than under any other circumstances, because it is claimed by a number of authorities, notably von Rehn, Crotti and Kocher, that in the condition known as status lymphaticus complicating Graves's disease the patient is much more likely to recover if this step is added to the thyroidectomy, so that in this class of cases, which has been looked upon as almost hopeless, quite a large proportion can be operated successfully if thymectomy is added to thyroidectomy.

Technic of Operation.—In case thymectomy is to be performed at the conclusion of thyroidectomy the transverse collar incision, which has been made for the removal of the thyroid gland, furnishes an ideal approach to the thymus gland.

[1] Biologie der Thymus Druese, Tübingen, 1910.

In case thymectomy is made as an independent operation the same incision should be made. The anterior muscles of the neck, sternothyroid, sternohyoid and sternocleidomastoid should be separated in the median line just at the upper end of the manubrium and carefully retracted; then the fascia extending from the thyroid to the thymus gland should be cut transversely when the upper end of the enlarged thymus gland will be seen bulging upward into view.

This is then seized with forceps and gently pulled upward out of the chest in case the gland is not strongly adherent. The blood supply must now be borne in mind as coming from the inferior thyroid, internal mammary and sometimes directly from the subclavian, hence the necessity of clamping these branches successively as they are brought up with the gland.

It is best to apply two pairs of forceps to each portion of tissue grasped to cut between these and to ligate carefully at once.

At the lower end there are usually small vessels from a cardiophrenic branch, which must be disposed of in the same manner. In this way the cavity can be left practically dry and the pressure from the surrounding tissues will cause the cavity to collapse immediately, making a closure of the wound the ideal plan.

In case the capsule of the gland is so strongly attached to the surrounding tissues as to make it appear unsafe to remove the capsule together with the gland, then the steps of the operation are varied in the following manner: The gland is drawn up as described above, but the capsule is split transversely and a finger is inserted between the parenchyma of the gland and the capsule and the former is enucleated with great care and gentleness. When a point of resistance is reached the gland is retracted to one side and two pairs of hemostatic forceps are applied to the point. The tissue grasped is cut and ligated doubly and the process is continued until the entire gland has been peeled out of its capsule.

The oozing is stopped by means of gauze tampons, which are left in place five minutes or longer, when the oozing will have stopped, and it will be safe to remove the tampon and permit the capsule to collapse as before.

In case a vein has been torn, which has not been clamped and ligated, it may become necessary to leave the tampon in place for two days and to permit its end to protrude from a small incision below the external incision, which should be sutured throughout.

This plan should, however, be followed only in case of absolute necessity, as most operators agree with Olivier in believing that the greatest danger comes from infection, and that this cannot be readily avoided in case any form of drainage or tampon is employed; for the same reason tracheotomy should not be performed in connection with this operation.

Anesthesia.—The same method of anesthesia which has been described in connection with the operation of thyroidectomy is most satisfactory for thymectomy.

INDEX

B

C

D

G

H

I

M

N

Q

R

T

U