The AMERICAN YEAR-BOOK of ANESTHESIA & ANALGESIA

F. H. McMECHAN, A.M., M.D.
EDITOR

The AMERICAN YEAR-BOOK *of* ANESTHESIA & ANALGESIA

1917-1918

To

JOS. MacDONALD, Jr., M. D.

(Late Major, U. S. Army M. C.)

THIS VOLUME IS
AFFECTIONATELY DEDICATED
AS A FRIENDLY TOKEN OF
REGARD FOR HIS VISION,
COURAGE AND INITIATIVE
IN PUBLISHING
The QUARTERLY SUPPLEMENT
& AMERICAN YEAR-BOOK *of*
ANESTHESIA & ANALGESIA

—*The Editor*

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1917 *Editor* 1918

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The AMERICAN YEAR-BOOK of ANESTHESIA & ANALGESIA

1917 EDITORIAL FOREWORD TO VOLUME TWO 1918

APPEARANCE OF the Year-Book for 1917-18 has been delayed by the exigencies and demands of the World War. Conditions of conflict also made it impossible to have the Year-Book as International in scope as had been hoped for. However, the Editor has been fortunate in being able to secure extended reports on almost all the worthwhile advances of anesthesia and analgesia in the surgery of war. This collection of data, with the verdict of the authorities who have gathered it, should at least persuade the heads of the various Allied Army Medical Services, that anesthesia was not handled as it might have been, had those in responsible positions been amenable to more immediate advice. On the contrary, some of the anesthetic methods. introduced to expedite military surgery, are finding a place for themselves in civilian practice for the benefit of all concerned.

Readers of this Year-Book will note with pleasure that fundamental studies in the pharmaco-physio-pathology of anesthesia and analgesia have not been neglected. In fact many of the studies along these lines are of exceptional merit. As many of them have a direct bearing on the clinical handling of patients submitting to operation under narcosis, they are doubly significant and valuable.

An effort has been made to collate papers dealing with the same subject or its pertinent phases. In so doing some duplication has occurred but differences of opinion, technic and research have not been eliminated. As stated previously, both the science and practice of anesthesia and analgesia are still in a condition of flux and many of the controversial disputes still need indisputable facts for their settlement.

Again the Editor of the Year-Book has attempted to make it appeal to all those progressive members of the allied professions and specialties, who in any manner come in contact with the science or practice of anesthesia and analgesia. Besides covering the progress during 1917-18 in these subjects, the Year-Book provides the anesthetist, dentist, research-worker and surgeon with those special advances that have a direct bearing on his individual requirements.

The innovation of the Advertising Section has been continued. So far no Anesthesia Foundation has eventuated, although recently some of the forward-looking manufacturers of anesthetics and apparatus have united to finance a National Anesthesia Research Society, which, it is hoped, if it can serve its expectations, will, sooner or later, become a Foundation. In an effort to stimulate interest in the teaching of anesthesia and analgesia in the medical and dental schools and clinical hospitals, the National Anesthesia Research Society is placing a presentation copy of the 1915-16 Year-Book in all the institutions in which these subjects are taught. This is intrinsic evidence of the position which the Year-Book has achieved.

The Publishers and Editor bespeak your good will and interested attention for the pertinent products in the Advertising Section, all of which conform to the highest standards. Owing to the greatly increased cost of production the cooperation and support of Year-Book advertisers has again been more than necessary.

The Editor wishes to thank all those, who, in any way have contributed to the context of the Year-Book. Its editing has again proceeded despite the inroads of protracted illness. This disability is being accepted as a dispensation for the special accomplishment of the Editor's work in behalf of the literature and organization of anesthesia as a specialty in the practice of medicine and dentistry. The Editor solicits the continued support of all those who appreciate the service which the Year-Book provides and anxiously awaits suggestions for making it more serviceable.

F. H. McMECHAN, M. D.,
Editor.

Curtis Farms,
Avon Lake, Ohio,
Thanksgiving Day,
1920.

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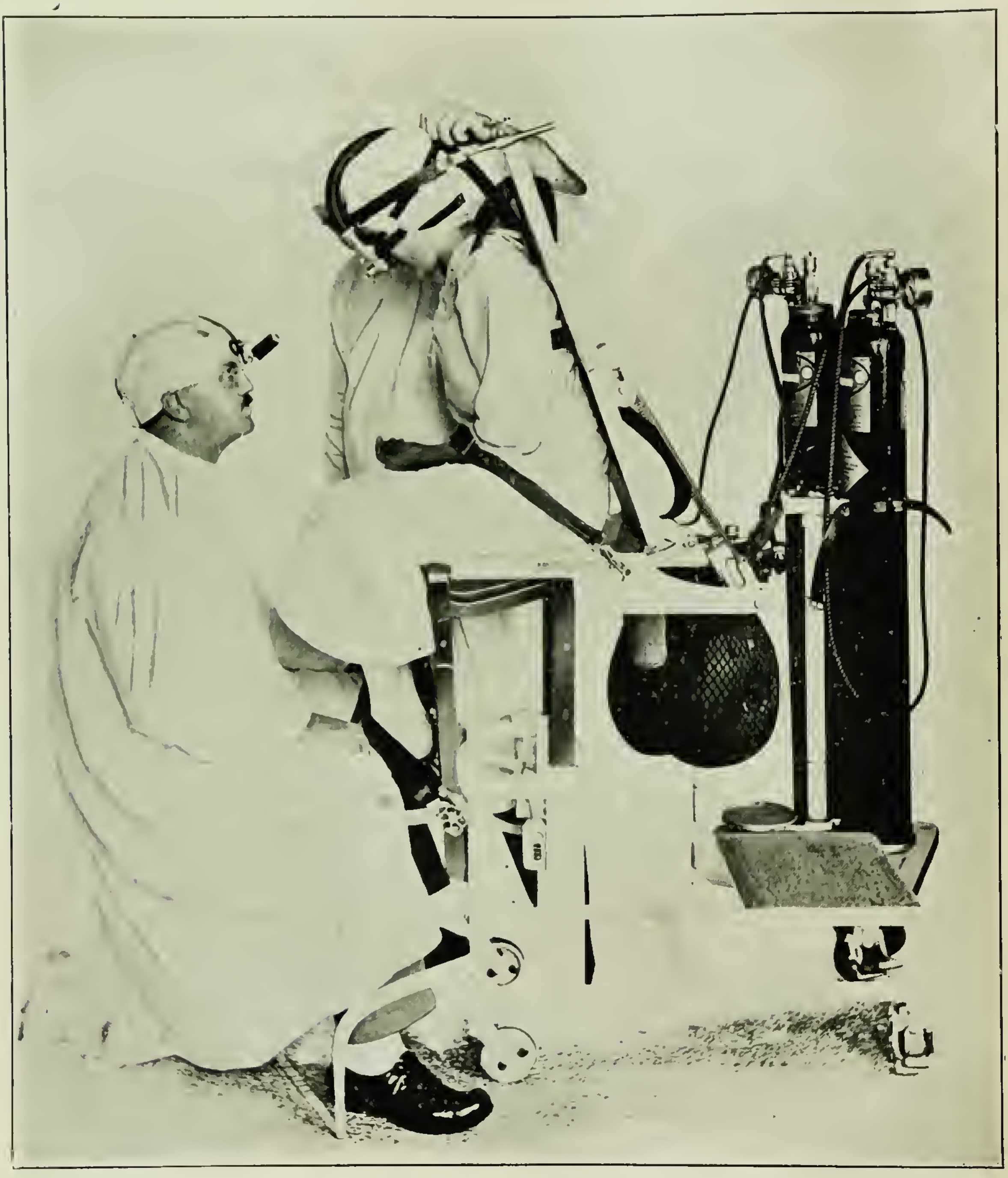
ENTHUSIASM IS THE DYNAMIC FORCE OF YOUR PERSONALITY. WITHOUT IT, WHATEVER ABILITIES YOU MAY POSSESS LIE DORMANT; AND IT IS SAFE TO SAY THAT NEARLY EVERY MAN HAS MORE LATENT POWER THAN HE HAS EVER LEARNED TO USE. YOU MAY HAVE KNOWLEDGE, SOUND JUDGMENT AND GOOD REASONING FACULTIES; BUT NO ONE—NOT EVEN YOURSELF—WILL KNOW IT, UNTIL YOU DISCOVER HOW TO PUT YOUR HEART INTO THOUGHT AND ACTION. A WONDERFUL THING IS THIS QUALITY WHICH WE CALL ENTHUSIASM. IT IS TOO OFTEN UNDERRATED AS SO MUCH SURPLUS AND USELESS DISPLAY OF FEELING, LACKING IN REAL SUBSTANTIALITY. THIS IS AN ENORMOUS MISTAKE. YOU CANNOT GO WRONG IN APPLYING ALL THE GENUINE ENTHUSIASM THAT YOU CAN STIR UP WITHIN YOU; FOR IT IS THE POWER THAT MOVES THE WORLD. THERE IS NOTHING COMPARABLE TO IT, IN THE THINGS WHICH IT CAN ACCOMPLISH. WE CAN CUT THROUGH THE HARDEST ROCKS WITH A DIAMOND DRILL AND MELT STEEL RAILS WITH A FLAME. WE CAN TUNNEL THROUGH MOUNTAINS AND OVERCOME ANY SORT OF PHYSICAL OBSTRUCTION. WE CAN CHECKMATE AND DIVERT THE VERY LAWS OF NATURE BY OUR SCIENCE. BUT THERE IS NO POWER IN THE WORLD THAT CAN CUT THROUGH ANOTHER MAN'S MENTAL OPPOSITION EXCEPT PERSUASION AND PERSUASION IS REASON PLUS ENTHUSIASM, WITH THE EMPHASIS ON THE LATTER. ENTHUSIASM IS THE ART OF HIGH PERSUASION. IF YOU WOULD BE A POWER AMONG MEN, CULTIVATE ENTHUSIASM. PEOPLE WILL LIKE YOU THE BETTER FOR IT; YOU WILL ESCAPE THE DULL ROUTINE OF A MECHANICAL EXISTENCE AND YOU WILL MAKE HEADWAY WHEREVER YOU ARE. IT CANNOT BE OTHERWISE, FOR THIS IS THE LAW OF HUMAN LIFE. PUT YOUR SOUL INTO YOUR WORK AND NOT ONLY WILL YOU FIND IT PLEASANTER EVERY HOUR OF THE DAY, BUT PEOPLE WILL BELIEVE IN YOU JUST AS THEY BELIEVE IN ELECTRICITY WHEN THEY GET INTO TOUCH WITH A DYNAMO. REMEMBER THIS—THERE IS NO SECRET ABOUT THIS GIFT OF ENTHUSIASM. IT IS THE SURE REWARD OF DEEP, HONEST THOUGHT AND HARD, PERSISTENT LABOR.

-J. Ogden Armour.



IRA O. DENMAN, M. D. *and* ELMER I. McKESSON, M. D.

DEMONSTRATING OPERATION AND NITROUS OXID-OXYGEN ANESTHESIA IN THE FORWARD INCLINED SITTING POSTURE, AS ESPECIALLY ADAPTED TO ORAL AND SINUS SURGERY.

ANESTHESIA IN THE SURGERY OF EPILEPTICS AND THE CONTROL OF STATUS EPILEPTICUS . BEHAVIOR OF EPILEPTICS UNDER ANESTHESIA . ASSOCIATED PATHOLOGY . ANESTHETIC MANAGEMENT . DEHYDRATION AND ALKALINIZATION . ANESTHETIC AGENTS . THE SURGERY OF EPILEPSY AND EPILEPTICS . CHLOROFORM, DROP-ETHER AND ETHER-RAUSCH . MENTALITY AND REACTION TO ANESTHETIC AND OPERATION . LOCAL ANESTHESIA . STATUS EPILEPTICUS . METHODS OF HANDLING SERIAL SEIZURES . VALUE OF CHLOROFORM IN ARRESTING CONVULSIONS AND CONTROLLING ATTACKS . RESPONSE OF PATIENTS TO TREATMENT . CASE REPORTS . CONCLUSIONS .

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G. KIRBY COLLIER, M. D. CRAIG COLONY SONYEA, NEW YORK.
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ADDRESSING THE Fourth Annual Meeting of the American Association of Anesthetists in Detroit, June 12, 1916, W. H. Mytinger revived interest in the problem of epilepsy as a complicating factor of anesthesia. Mytinger's data were gathered from a series of 100 cases of epilepsy (idiopathic) and 50 cases of viceroptosis, in which he administered anesthesia during a period of 6 months, as anesthetist to C. A. L. Reed, of Cincinnati.

"Had the period been one of years, instead of months," said Mytinger, "the excuse for this paper would probably not have arisen for it has been the constant recurrence of certain phenomena, day after day, which has enabled me to draw certain conclusions."

BEHAVIOR OF EPILEPTICS UNDER ANESTHESIA.

JUST AS IN his everyday life the epileptic presents marked clinical peculiarities, so also in his anesthetic existence we encounter deviations from the average clinical type. The convulsive seizure so essentially bound up with the disease itself is almost constantly to be dealt with in a more or less modified form and presents the chief difficulty to be overcome.

Constipation.—Habitual constipation due to the pronounced viceroptosis which is constantly present is the rule. This leads to a sluggish circulation and to a reduced power of oxygenation.

Acidosis.—An extreme acidosis is present, probably of infectious origin and heightened by the appearance of the epileptic attack. The salivary secretion turns blue litmus red and even after prolonged alkalinization this reaction remains unchanged.

Reflexes.—The convulsive seizures under anesthesia show a wide range of variability both as to their nature and as to their number and also as to their time of occurrence and their duration. Profuse salivary and mucous secretion characterize the attack. The swallowing and laryngeal reflexes are excessively active and peculiar throaty sounds are heard which one feels at a loss to describe. The eyes may deviate and lateral nystagmus is often present. The pupils as a rule are contracted and equal, although occasionally one pupil is contracted and the other dilated, while only rarely does one see both pupils dilated which I believe is the rule when the attack ordinarily occurs. The lid reflexes become very active and are entirely independent of external stimuli. The facial muscles may all be involved in this muscular excitation.

The jaws may be firmly locked together and may be fixed over the tip of an enormously hypertrophied tongue which presents excoriations and scars from previous seizures. At other times there is a convulsive grinding of the teeth. At times the tongue muscles are involved and when this organ is hypertrophied and forcibly drawn backwards the act of respiration is almost at a standstill.

Cyanosis.—Cyanosis of an extreme degree develops rapidly, giving the appearance of impending death for lack of oxygen and which passes rapidly with the lessening in intensity of the attack. The respirations are usually of the stertorous type and are embarrassed to a greater or lesser degree. Both the rate and the depth of respiration are subject to great variability.

Epileptic Cry.—Occasionally the epileptic cry is heard. This occurs as a rule during induction, but on two occasions was distinctly audible during the stage of maintenance. During the induction with the onset of a seizure the skeletal muscles may be involved. Those of the back of the neck, the upper and the lower extremities being frequently affected. At times these muscular spasms occur during the stage of maintenance. They may be either clonic or tonic in type, the former type predominating.

Circulation.—The pulse rate and pulse volume are peculiarly independent of the paroxysms. When one sees a deeply cyanotic patient struggling for breath, he is surprised to find a heart attending to business just as though nothing were going on which concerned it. A rise in rate is noted but not commensurate with the respiratory embarrassment and readily explained on the basis of muscular activity.

Seizures.—As to the number and time of occurrence of the seizures we find a wide range of variation. On two occasions they were absent entirely. Usually at least one seizure occurs during the induction. This may end the attacks for a given case or there may be a series of attacks of longer or shorter duration extending throughout the entire course of the anesthetic. At times there may be an almost continuous chain of seizures with their varying manifestations. It is not an uncommon thing to see the surgeon working in a perfectly relaxed abdomen with the patient blinking his eyes, breathing spasmodically and at times shaking the table with tonic convulsions of the skeletal muscles.

ASSOCIATED PATHOLOGY.

As regards the pathological findings visceroptosis of a high degree is constantly present. This is accompanied by a marked relaxation of the muscles of the jaw, tongue and upper respiratory tract. This relaxation is not comparable to the relaxation encountered in the anesthetic state with the ordinary case. It is so extreme that, in the writer's opinion, it is pathological. This phenomenon has been so constant in all of these cases of epilepsy and also in a series of visceroptosis cases uncomplicated by epilepsy, that the writer is led to venture the opinion that the ptosis is not confined to the abdomen, but that all the ligaments of the body are probably involved. Indeed, on several occasions where this degree of relaxation was encountered and the diagnosis of visceroptosis had not been made prior to operation, I have ventured the diagnosis when the patient was put on the table and it has been verified on abdominal section. The value of this observation is that, given a known case of visceroptosis to anesthetize, we can anticipate a mechanical interference with respiration. The truth of the observation I leave to the test of time.

OPERATIVE AND ANESTHETIC MANAGEMENT.

As regards the anesthetic management of these cases they are uniformly difficult subjects to handle. Prolonged preoperative treatment preferably in a sanatorium or in the home where the atmosphere is conducive of mental quiet and physical rest is desirable. Any influence tending towards excitement of any kind shoud be done away with.

Intravenous alkaline and dehydration medication should be utilized to combat the existing acidosis over a period of ten days to two weeks before the operation. At the same time bromides or other sedatives should be freely resorted to and frequent courses of vigorous catharsis including high enemata should be employed. At times even after the most careful and persistent efforts to cleanse the intestinal tract on examining the colon at operation it is found practically loaded with hard scybalous masses. A hypodermic of from $\frac{1}{6}$ to $\frac{1}{4}$ gr. morphin sulphate with $\frac{1}{150}$ gr. atropin sulphate has been used in adult cases as a routine. It is of value in combating the excessive secretion and allaying the severity of the convulsive seizures. Due to the sluggish circulation the absorption seems delayed and the best results have been obtained when given about one hour and fifteen minutes prior to operation.

CHOICE OF ANESTHETIC.

As TO THE anesthetic agent to be employed I shall not attempt to lay down any rules. I shall merely give my own procedure and the reasons why I have adopted it.

With the existing high degree of acidosis present nitrous oxid-oxygen would seem to be the anesthetic of choice. However, due to the sluggish circulation, these patients oxygenate poorly. It is exceedingly difficult to maintain abdominal relaxation, so important in these cases, by means of gas-oxygen even when accessory nerve blocking is employed. As a consequence, in order to maintain proper surgical anesthesia and to control the convulsive seizure, one must resort freely to the use of the ether attachment so that the advantages to be derived from this method do not seem to the writer to offset its disadvantages, the least of which is the much greater cost to the patient.

Most of the standard authorities advise the use of chloroform in patients of this class. Chloroform by inhalation is an old remedy for so-called uncontrollable convulsions. Having seen convulsive seizures appear during the stage of maintenance with ether narcosis, I believe that the pushing of chloroform to the point of abolishing the convulsive attack would be dangerous in the extreme.

I have then resorted to the use of ether in these cases using the nitrous oxid-ether sequence with the Bennett inhaler supplementing with oxygen when indicated. A reasonably smooth anesthesia is obtained and there is no inconvenience to the operator. The induction period is prolonged, due in all probability to the sluggish circulation, to the resultant delayed absorption and often to the necessity of waiting for a convulsive seizure to subside before taking the patient into the operating room.

With the onset of an attack during induction a high degree of cyanosis may rapidly develop and it is often necessary to apply the tongue clamp and resort to the use of the pharyngeal tube. In some instances strong support of the jaw will suffice in maintaining an open airway. Throughout the stage of maintenance one must be constantly on the watch for the appearance of convulsive manifestations. The after care of these patients presents no particular difficulty other than the maintenance of an open airway and the nurse should always be instructed to support the jaw until the patient is pretty well out of his anesthetic.

After having administered anesthesia to a number of these patients one gets the impression that he gives a double anesthetic, one to the patient and one to the disease itself for, after the induction has proceeded quietly almost to the stage of narcotization, a convulsive seizure appears and it seems that one begins all over again.

CONCLUSIONS.

IN CONCLUSION, I wish to emphasize the fact that these cases are not choice ones, from an anesthetic standpoint, on which to display your anesthetic prowess. The uninitiated will blame the anesthetist for the epileptic manifestations whatever they may be, even though these are entirely outside of his control. However, one who handles these cases can at least have the satisfaction of work well done for he alone knows and appreciates the difficulties which he has had to surmount.

AN EXTENDED EXPERIENCE in handling epileptics at the Craig Colony, Sonyea, N. Y., has enabled G. Kirby Collier to amplify Mytinger's clinical observations. Appearing before the Third Annual Meeting of the Interstate Association of Anesthetists at Toledo, Ohio, October 9-11, 1917, Collier emphasized that:

Surgery as a therapeutic aid is as necessary in the epileptic as it is in his non-epileptic brother, and therefore we have to consider the use of some anesthetic or anesthetics to assist us in such surgery. This class of patient is subject to the same variety of physical ills as is his normal brother, and he requires similar surgery for the relief of these. He is the victim of appendiceal troubles, gall-bladder disturbances, intestinal conditions demanding surgical therapy, fractures, and the full list of surgical disorders requiring operative interference. He is as a result of his disease, subject, more so than his normal brother, to injuries of all kinds, and only in special institutions, where every effort is made to carefully supervise the patient's daily régime, is there any lessening of this risk, and even there, we find a multiplicity of injuries, ranging from a slight lacerated wound to cranial fractures. Following intensive medical treatment, there are various metabolic disturbances, which at times necessitate surgical therapy. As a therapeutic measure, surgery in the treatment of epilepsy has been practiced since the earliest recognition of the disease, and the unfortunate sufferer from epilepsy has been the prey of the surgeon since the earliest times.

A varied list of operative procedure has been in vogue with the surgeon at one time or another, and there are but few epileptics who have not at one time or another during their epileptic life been referred to the surgeon, who fortunately has been able to see the futility of many of the operative procedures which have been recommended.

SELECTION OF ANESTHETIC.

AS FOR THE anesthetic to be used in operations done upon the epileptic, we believe this to be a matter for individual choice, and as indicated by the condition of the patient. We have used both chloroform and ether in our surgery at the Craig Colony for Epileptics, and our experience has taught us that ether, by the drop method, is very well borne by the epileptic, and the greater number of our anesthesias have been obtained with this agent and method. Chloroform has been used largely in any operative work about the head, and in children, we have found this to be most satisfactory. For the reduction of dislocations, the opening of abscesses, and other work requiring only a short period of anesthesia, we have used the so-called Ether-Rausch. The induction by this method is most rapid and there is a very quick recovery. We have seen no ill results follow upon the use of the method.

MENTALITY AND REACTION TO ANESTHETIC AND OPERATION.

IN OUR DEALINGS with this class of unfortunates, we have a peculiar type of mental make-up to deal with, ranging from that of the mentally normal to the egocentric and downward to the imbecile, and we should always keep this fact in mind. We do not find the epileptic patient to be any more difficult to handle on account of his epilepsy, *per se*, than any other class of patient. We do find, however, that the mentally-defective epileptic, not realizing the importance of fully cooperating with the surgeon and his assistants, is very difficult to handle, removing dressings and infecting wounds.

Seldom do we find that there is any increase in the frequency of the convulsive attacks after any operative procedure. On the contrary, the epileptic convulsive attacks are less frequent in their occurrence, this being due, we believe, to the better hygienic care given to the surgical cases both prior to and following any operative treatment, and not to any effect of the anesthetic.

In only one case in our series, running over a number of years, have we seen a period of mental confusion of the active type, following upon a surgical anesthesia. This occurred in a man, aged forty-five years, operated upon for the relief of a large, right inguinal hernia. This patient was markedly defective mentally, requiring close supervision at all times, his mental grade being that of a child of about ten years of age. Following operation, this patient had a period of active mental confusion, during which he removed the dressings from the adbomen and opened the abdominal wound, with fatal results. Other than this one case, we have seen no unfavorable results following any surgical procedure, which could be blamed to the fact that the patient was epileptic.

SEIZURES DURING ANESTHESIA.

IT HAS NOT been noticed that the period of induction of the anesthetic state has been increased, and neither is it the rule for us to see a convulsive attack occurring during the period of induction. In the hands of a competent anesthetist we find the induction period to be as quiet and as peaceful as is met with in the case of the non-epileptic.

In fact, we recall but one case in which a seizure occurred during operative interference. This was in the case of a young man, on whom a fenestration of the dura was done. The operation was performed in two stages. At the first, the skin incision was made, after which trephine openings, the latter being connected with a Gigli saw. The wound was then closed and the second operation done about ten days later. At this time, the osteoplastic flap is turned back, and a fenestration of the dura made. At the time of the second operation, while the patient was under light chloroform anesthesia, and the skin wound was being reopened, a mild or incomplete convulsive attack occurred, but all convulsive movements ceased when the anesthetic was pushed to the physiological limit.

It should be remembered here, that all of our anesthesias have been induced with one anesthetic, the one agent being used throughout the operation.

We have used local anesthesia for various operations, both minor and major, including operations upon the abdomen, such as hernias and appendectomies, and have seen no convulsive attacks occur at such times. This may have been due to some psychic influence, or it may have been purely a matter of luck with us.

STATUS EPILEPTICUS.

IN THE TREATMENT of that condition known as status epilepticus and serial seizures, we have to resort to some anesthetic in order to control the frequently recurring convulsive attacks. Chloroform we have found to be the most useful in our hands, and we have always endeavored to bring it into use early in the condition.

The anesthetic state is of great assistance in the treatment of status and serial epilepsy in that it allows of time for other methods of treatment to be carried out, such as the use of colonic irrigations, lumbar puncture and the administration of chloral and bromides per rectum. We have not hesitated to use chloroform frequently in any single case, but ether we have been somewhat fearful of owing to the possibility of increasing the ever-present pulmonary edema.

Finally, we wish to make a plea for the epileptic, and would suggest that no operative procedure, when necessary, be delayed or abandoned, owing to the fact that he or she suffers from a convulsive disorder. With the assistance of a competent anesthetist in the operating room, and the tact and good judgment of an intelligent nurse at the bedside, we feel that the epileptic will be found to be a far more amenable patient to handle than he is generally thought to be.

CONCLUSIONS.

1. The epileptic, *per se,* is a good anesthetic risk.

2. Convulsive attacks are not met with when ether or chloroform is used to the surgical limit.

3. Chloroform is a valuable aid in the treatment of status epilepticus, and should be used early in the condition, so that other therapeutic measures can be instituted.

REPORTING HIS STUDY of some interesting cases of status epilepticus to the American Medical Association during the Detroit Meeting, 1916, Leigh F. Robinson, of Raleigh, North Carolina, dilated on the utility of chloroform in arresting serial seizures and in diminishing the severity of the convulsions. On account of the value of his report it is given in detail as presented in the Journal of the American Medical Association, November 18, 1916:

By status epilepticus, reference is made to that condition of epilepsy which is characterized by epileptic seizures following so close one on the other that before the patient finds himself out of one convulsion the successive attack appears, and so on until death, unless by some means they are arrested.

At the New Jersey State Village for Epileptics, I made a study of the treatment of status epilepticus in cases selected from the children's division. All patients who had status epilepticus were studied. The study was made between March 1 and December 1, 1915.

Prior to this study, the treatment of the status epilepticus cases was with purgation and high colon flushes, large quantities of water being used long after the colon had been cleansed. When necessary, relaxation was produced with chloroform to the state of primary and sometimes of complete anesthesia, and bromides and chloral hydrate were occasionally used during the intervals.

PLAN OF STUDY.

THE PRESENT STUDY was made to ascertain which of these remedies was the most potent, or whether all together gave the results. The study was divided into first, second and third parts, the first part to cover the first three months, the second part the second three months, and the third part the last three months. The plan of study pursued was the use in the first part of high colonic irrigation with saline purgation and to avoid the use of chloroform. In the second part the same procedure was to be followed, but chloroform anesthesia was used whenever the enemas and purgation failed. In the third part chloroform anesthesia was used alone and as soon as the physician arrived. As will be observed throughout the report, an absolute adherence to this plan was not possible owing to the frequency with which the patient's condition demanded a slight variation of the treatment.

All of the patients except Case 7 at the beginning of the study were placed on fluid extract of cascara sagrada each day at bedtime, and a saline purgative or castor oil was administerd about every ten days.

CASE REPORTS.

The following case reports will show the results:

CASE 1.—*History.*—B. C., girl, aged 12, in whom the first convulsion occurred at 5 months, exciting cause not known, had a neurotic hereditary taint. The Binet-Simon test gave the mental age as 4.8 years. The patient had been having status epilepticus on an average about once every three to five weeks. The status was usually preceded by violent pain in the back.

First and Second Parts.—Three status attacks occurred approximately on an average of four weeks apart, and were treated in the beginning with high colon irrigation. In the first status, no chloroform was administered; during the second and third, owing to the patient's becoming very much exhausted, enough chloroform was given for relaxation.

Third Part.—The last three months, as soon as the physician arrived at the bedside, chloroform was administered, which each time arrested the seizures with the same good after-results as when high enemas were used. Just enough chloroform was inhaled to relax the patient, at which time she would go to sleep and after a few hours awaken in her usual condition.

CASE 2.—*History.*—E. P., girl, aged 17, whose first convulsion occurred at 10 years, the exciting cause being indigestion, carried an epileptic hereditary taint and tested 2.6 years by the Binet-Simon scale. This patient had been having status about every four to five weeks.

First and Second Parts.—This study of the patient shows that from the first convulsions she recovered without the use of chloroform, but during the second and third it was necessary as a last resort. This patient always vomited shortly after the administration of chloroform, which seemed to relieve her and showed an overloaded condition of the stomach. After relaxation with chloroform she would have two or four convulsions within the next twelve hours, which were all except an occasional one until the next status.

Third Part.—The next four status convulsions were treated without enemas and chloroform was administered immediately on the arrival of the physician, which arrested convulsions with the same results as when the enemas were used in conjunction with the anesthesia.

Case 3.—*History.*—M. R., girl, aged 14, whose first convulsion occurred at 5 years and was attributed to teething, had both a maternal and a paternal neurotic taint, and stood one-plus results by the Binet-Simon scale. She had status epilepticus every one to three months.

First Part.—Two attacks occurred, and it was necessary to administer chloroform in both attacks, which came on two months apart. Both times the patient became very cyanosed, and as soon as the chloroform was administered began to breathe easier and soon completely relaxed, without recurrence of convulsions. Each time she had a great deal of bronchial secretions, and the pulse became rapid and weak, which condition was relieved by atropin.

Second Part.—It was quite evident that the longer the chloroform was withheld the more chloroform it took to relax the patient.

Third Part.—The chloroform was administered at once and the patient relaxed early. The after-effects were very much diminished in that the patient was able to be up and about much earlier.

Case 4.—*History.*—A. M., girl, aged 11, whose first attack occurred at the age of 3 years, exciting cause unknown, was epileptic because of a defective germ plasm carrying a maternal epileptic and a paternal feeble-minded taint. The Binet-Simon test gave a mental age of 3.9.

First and Second Parts.—In the first attack, chloroform was not administered. The second attack was very severe and colon flushes and chloroform would relax her for only a few minutes, sometimes as long as an hour, and then there would be a recurrence of the convulsions. This state of affairs lasted for about forty-eight hours, when the convulsions became arrested. During the time, bromides. chloral and morphin had been administered. The patient was in bed several weeks following this attack of status.

Third Part.—In this part, chloroform was administered immediately on the beginning of the status, which arrested the convulsions without any of the former symptoms.

Case 5.—*History.*—M. C., girl, aged 10, whose first convulsion occurred at 8 months, exciting cause not known, had the hereditary taint of alcoholism on both sides of the house. The Binet-Simon test gave the mental age at 2 years.

First and Second Parts.—In this part of the treatment, chloroform was administered in only one out of three status attacks. There was apparently no difference in the recovery of any of the three attacks. There were one or two convulsions during the first twelve hours following the arrest of the status. The patient was able to be in her usual condition the following day.

Third Part.—This part of the treatment with the immediate use of chloroform showed an early arrest of the convulsions with the same after-effects as in the first and second parts.

Case 6.—*History.*—L. T., boy, aged 12, whose first convulsion occurred at 18 months, exciting cause unknown, had no hereditary taint which had been ascertained. The Binet-Simon test gave the mental age as 2.5 years. This patient had status epilepticus every three or four months, and had only two attacks during the study.

First and Second Parts.—In the first attack the patient was given high colonic irrigation, but owing to his cyanotic condition, chloroform was administered after about forty minutes. Shortly after the effects of the chloroform wore off (about fifteen minutes) he went into convulsions again. Chloroform was administered a second time with no better results than the first. The patient had twenty-six convulsions in about three hours. He was given bromides, chloral hydrate, high enemas and three administrations of chloroform before he finally became relaxed and went to sleep.

Third Part.—Only one attack occurred, at which time the patient commenced convulsing at 4:45 in the morning, and chloroform was administered, enough to relax the patient, but not enough to produce anesthesia. The patient went back into convulsions in about ten minutes, and chloroform was administered again at about 5:44, at which time he relaxed and began to breathe easier, and apparently the convulsions were arrested; but in about ten minutes he went into convulsions for a third time. Chloroform was given again with no better results. At 8 o'clock a high enema was administered which revealed considerable constipation. Several gallons of water were used until it came out clear. The patient's convulsions diminished, and at 9:20 ceased altogether.

Case 7.—*History.*—J. G., boy, aged 17, whose first convulsion occurred at 18 months, and was said to have followed a cranial operation, carried a maternal neurotic taint. His Binet-Simon age was 8.2 years. During the study the patient had three attacks of status epilepticus.

First and Second Parts.—The first attack was treated with high colonic flushes, and chloroform was used only after the patient became very cyanosed and showed no signs of relaxation.

Third Part.—In the other two attacks the patient was chloroformed immediately on the arrival of the physician. He relaxed at once and had no more convulsions after administration of the chloroform. No cascara was given this patient as a regular routine. In this part of the study a purgative was given a few hours after the occurrence of status, and both times the patient was found to be in a constipated condition, which, however, did not interfere with the expected results from the chloroform.

CONCLUSIONS.

1. The records prior to the study show that

this treatment produced no decrease in the frequency of the status attacks.

2. In most cases the data during the study show that despite changes in the routine of treatment, the occurrences of status attacks came at the close of fairly regular intervals.

3. The length of the time required for the average patient to recover from the effects of status depended on how soon the attack was arrested, and was in the same ratio.

In view of these facts, the following deductions are made:

1. Chloroform should be administered early in practically every case of status epilepticus.

2. Although this study showed that most patients would not benefit materially by high enemas and the regular use of laxatives, it is advisable along with the use of chloroform to employ proper measures to overcome any tendency toward constipation.

THE ESSENTIALS FOR SUCCESS IN THE PRACTICE OF ANESTHESIA ARE PERSONALITY, ABILITY AND EQUIPMENT. NO ANESTHETIST EVER MAKES A REAL SUCCESS OF THE SPECIALTY WITHOUT CONVINCING PATIENTS OF AN INHERENT DESIRE TO TRULY SERVE THEM. PERSONALITY CANNOT BE EXPRESSED IN MERE WORDS; IT MUST SHINE FORTH IN THE STERLING CHARACTER OF THE ANESTHETIST AND MUST EVIDENCE ITSELF IN EVERY ACTION IN BEHALF OF SUFFERING HUMANITY. THE MEASURE OF THE ANESTHETIST'S ABILITY DEPENDS UPON ADEQUATE EDUCATION, NATURAL ENDOWMENTS, AN APTITUDE FOR THE SPECIALTY AND CONSCIENTIOUS WORK. ABILITY NOT ABOVE THE AVERAGE AND LEFT UNDEVELOPED EVENTUALLY FAILS OF ACHIEVEMENT. NO ANESTHETIST WITH THE PRIDE OF ABILITY OR THE DESIRE FOR EXCEPTIONAL SERVICE WILL HANDICAP SUCCESS BY FAILING TO PROVIDE ALL THE LATEST AND BEST EQUIPMENT FOR THE PRACTICE OF THE SPECIALTY. THIS IS NOT MERELY A PRIVILEGE BUT A DUTY.

THE HANDLING OF CHILDREN WITH TUBERCULOSIS OF THE SPINE WHILE UNDER THE INFLUENCE OF AN ANESTHETIC . ANATOMICAL CONSIDERATIONS . SELF-PROTECTION AND ETHER RELAXATION . BUCKLING OF THE SPINE . ITS DANGERS . CASE REPORTS . METHOD OF PLASTER JACKET PROTECTION DURING OPERATIONS . EXTREME CARE NEEDED . CONCLUSIONS DRAWN FROM CERTAIN OBSERVATIONS AND UNTOWARD RESULTS .

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THE IMPORTANCE OF EXTREME CARE in the handling of children with tuberculosis of the spine was emphasized by Walter G. Elmer, of Philadelphia, in speaking before the Philadelphia Academy of Surgery, March 6, 1916, and later before the Fifth Annual Meeting of the American Association of Anesthetists, in New York City, 1917. Publishing his observations in the Annals of Surgery, July, 1916, and in the New York Medical Journal, September 29, 1917, Elmer contends that:

It is possible that we have not heretofore given enough consideration to the fact that a child suffering with tuberculosis of the spine, and while conscious and in full control of its voluntary muscles, is a very different object from the one which lies unconscious and relaxed under an anesthetic.

ANATOMICAL CONSIDERATIONS.

THE SPINAL COLUMN is deeply imbedded in and supported by the intrinsic and extrinsic muscles, and these, being under voluntary control, can instantly change the spine from a pliable and yielding column into a firm and unyielding one. This power of voluntary control and self-protection is, of course, entirely lost under an anesthetic. Likewise, the reflex muscle spasm is also lost. It is, however, the voluntary control, and the loss of it, which is the important feature.

Therefore, the spine of a child who is conscious and in full voluntary control of his movements might be compared to a watch-chain imbedded in paraffin. Under these circumstances the watch-chain could be lifted by both ends without its sagging, or one end can be rotated between thumb and finger, and the whole chain rotates in corresponding fashion. But if the paraffin is melted, the chain once more becomes limp and sagging, link moves in link, torsion at one end is gradually communicated from one link to the next until the limit of motion is reached, and so on throughout the length of the chain until perhaps one end has been rotated several times.

SELF-PROTECTION AND ETHER RELAXATION.

AND SO WHEN handling a normal child we find the same condition. We lift the child in our arms and he naturally and instinctively makes a bridge of his backbone across our supporting arms. And the same is true of torsion of the spine—he instinctively resists it.

If this is true of a normal child, it is even more marked in one whose spine is diseased. Here all the elements of self-protection and guarding against injury are amplified, the child's nervous system is hypersensitive, and carefully but positively does he voluntarily protect his weakened and tender spine when he is lifted or turned over.

Under the relaxing effect of ether anesthesia this power of self-protection is lost and the spine sags and bends when the child is lifted, and torsion at one end of the spinal column is carried segment by segment the length of the spine, one vertebra rotating on the next one, to the limit of motion, and so on down. So we have the analogy to the watch-chain.

Now let us imagine that we have removed the spine from a child suffering with Pott's disease, and as we hold it in our hands we examine it. What do we find? Here is one with a rather sharp, angular kyphosis at the tenth dorsal vertebra. The body of the tenth dorsal has entirely disappeared, the anterior edge of the body of the ninth is resting upon the anterior edge of the body of the eleventh and in the triangular space thus formed by the bones is the soft cheesy material—the tubercular débris of the disease—and it is also under tension, for the periosseous and periarticular structures are bulging at the sides and may at any moment give way. For the retaining walls are rotted through and through, they are weak and friable, and serve only as a feeble barrier to protect the surrounding tissues. But the plastic exudate and organized lymph are doing what they can to reinforce the protecting wall. The age of this child may be perhaps three or four years.

BUCKLING OF THE SPINE.

LET US TAKE up another specimen—the spine of a child about ten or eleven. Here a different condition prevails. There is rather an obtuse kyphosis in the lower dorsal region, involving the ninth, tenth and eleventh vertebræ. The body of the tenth has entirely disappeared, the intervertebral cartilages have been absorbed, the disease has been making inroads into the inferior portion of the body of the ninth and the superior portion of the body of the eleventh, but these two bodies are not resting the one upon the other, as in the previous case, but are separated by a considerable space. This space is filled completely with the soft mass of tubercular material, and as it is under some tension, it has forced its way into the spinal canal, entirely surrounding the spinal cord, and yet is held in restraint by a limiting wall of plastic exudate which prevents its free escape into the spinal canal. The contrast between this spine and the previous one is very striking. Why is it that in the one case bone rests upon bone, while in the other there is the wide gap between the bodies? The history tells us that this latter child was treated for many months lying supine upon a Bradford frame, and there is every evidence that the disease continued to make progress in spite of the treatment. Now if pressure be made upon the ends of this spine it easily buckles at the apex of the kyphosis; that is, it closes as a hinge would. The increased pressure upon the abscess must cause it to rupture at its weakest point, just as the artist, pressing in the sides of his tube of paint, expels the paint upon his palette. The abscess, therefore, may be expressed into the surrounding tissues, or into the spinal canal, or even into the spinal fluid itself, thus setting free in the cellular tissues and their lymphatics, or in the spinal fluid, large quantities of toxins.

ITS DANGERS.

IN REGARD TO the first spine, where bone rests upon bone, very little harm would result from pressing the ends of the spine together. But by making traction upon them the opposite effect is produced. The ligamentous structures, necrotic from the disease, easily tear and give way and the spine straightens, the kyphosis opening at its apex like a hinge, and tubercular material with its toxins may be set free in the surrounding cellular tissues and taken up by the lymphatics.

There is another factor to be considered. The intimate relationship of the great, the lesser and the smallest splanchnic nerves to the thoracic vertebræ is important. When we consider the situation of the sympathetic ganglia from which these nerves arise—the intercommunication between these ganglia and the spinal nerves and the spinal cord—the fact that these sympathetic nerves lie in such close contact with the bodies of certain of the vertebræ and terminate in the solar plexus and renal plexus, and further, that the ganglia themselves are directly connected with the bodies of the vertebræ by nerve filaments which pass into the bone, then we can see what effect traumatism in this region must have upon the general condition of the patient. Stretching and tearing of these delicate nerve structures so close to the spinal axis may produce sudden and severe shock. Likewise compression or pinching of the nerve tissue may produce shock.

CASE REPORTS.

Case 1.—A child of three, with a moderate angular kyphosis in the lower dorsal spine, is considered a suitable case for a bone-grafting operation. His condition remains good throughout with very little disturbance of his pulse or breathing. When it is time to apply the plaster bandages the patient is lifted from the table by the shoulders and pelvis. His trunk sags forward into hyperextension and a perceptible change takes place in the contour of the kyphosis. It has diminished. The plaster was put on rapidly and carefully, and perhaps not more than five minutes passed until it was completed; and yet, during the interval, the child changed from a condition of safety to one of shock. The change itself came very quickly and without warning, and he gave his doctors considerable concern until reaction was finally established. In this young patient with tender and delicate structures, weak and friable from disease, we believe there was an actual though slight giving way of the spine at the apex of the kyphosis; or in other words, it opened a little as a hinge would open. The child's temperature, which had been running close to the normal previous to the operation, reached 104° on the second day and then gradually declined, and his condition became entirely satisfactory.

Case 2.—A child of ten or eleven had had tuberculosis of the spine for several years and had not done well. Her resistance was poor. She was put to bed on a Bradford frame, with extension on her head and lower limbs. Both lower limbs were paralyzed. After a year and three months of this treatment she was still paralyzed.

Dr. Spiller then saw her in consultation with me. From every point of view the case was not promising. But we concluded that if the spine could he made rigid by bone grafting, it would give her the best chance for improvement, and we hoped that eventually the pressure on the cord might be relieved and she might regain the use of her lower limbs. We at least had hopes of seeing her up in a wheel-chair. It seemed to me that she could be carried safely through the operation. The mother was very anxious to have anything done which promised even a little improvement.

A plaster jacket was made on the day preceding the operation and cut down both sides, so that it could be quickly and easily applied the moment the operation was completed.

At the time of the operation the child was handled with the utmost care. She was lying prone upon the table, completely relaxed under the anesthetic, and we were about to proceed with the second step of the operation—that of inserting the bone-grafts into the spinous processes—when an unforeseen thing happened. Our anesthetizer, thinking the child was lying a little too near the head of the table, pushed her by the shoulders. Instantly the spine buckled. That is at the apex of the kyphosis it folded together like a hinge. Very carefully we straightened her out again into her former position and proceeded with the operation. In cutting longitudinally from the base of one spinous process to the base of the next one, just about at the apex of the kyphosis, some tubercular material was seen. The child was severely shocked by the time the operation was completed. She was put into the plaster jacket and back to bed. She gradually reacted and we began to feel hopeful for her recovery. The next day her temperature was 105° and our hopefulness changed to doubt. The day following her temperature reached 105⅗°, and we were completely discouraged. There was no sign of pneumonia, no evidence of meningitis. The patient died on the third day.

I must assume the responsibility for the child's death. I do not know definitely the cause of her death. It is not my purpose either to criticize or to censure. It is possible, however, that we have grown too accustomed to think of a kyphosis as a compact mass of bone.

METHOD OF PLASTER-JACKET PROTECTION DURING OPERATIONS.

If THERE IS an undercurrent of truth in the points which I have endeavored to bring out, how can we guard against these accidents?

The solution seems simple enough.

On the day preceding the operation the child should be placed prone upon a muslin hammock stretched fairly taut, but sagging a little with the child's weight. The body is swathed with a layer of cotton and, if desired, the pelvis protected with a girdle of felt and likewise a strip of felt on each side of the ridge of the spine, to prevent pressure on the tips of the spinous processes. The plaster-jacket is then applied and cut down each side in the midaxillary line.

At the time of the operation the child is placed supine upon the table, the front of the plaster-jacket is then removed, and the anesthetic started. (A child should never be given an anesthetic while the thorax is completely enclosed in a plaster-jacket.) A few minutes later the front of the jacket is replaced and held firmly in place by two assistants, while the child is turned over into the prone position. The back of the plaster-jacket is removed, the operation performed upon the spine, a light gauze dressing put on, and the back of the jacket with its cotton replaced, fastened firmly with girdles of adhesive plaster, and the child returned to its bed.

In this way all twisting and unnecessary movements of the spine are avoided.

We have often watched two assistants—perhaps the etherizer and a nurse—turning a child over on the operating table. Almost never do they act in perfect accord. The shoulders are turned a little before the pelvis or the pelvis a little quicker than the shoulders, and consequently there is the inevitable twist or torsion of the spine. The simple measures which I have outlined will effectually guard against this.

CONCLUSIONS.

AND SO I HAVE COME to believe that, *first,* the operation of bone-grafting upon the spine of a child is of itself accompanied by comparatively little shock.

Second, these children bear the anesthetic surprisingly well, providing, of course, it is properly given; and

Third, the handling of these children with diseased spines while they are relaxed under the anesthetic is the most vital point in the whole procedure.

GREAT MEN COUNT NOT THE COST WHEN CONFIDENCE SPURS THEM ON. THE DUNGEON HAS BEEN THE DWELLING OF MANY A LONELY GENIUS WHOM LATER THE WORLD HAS ACKNOWLEDGED, BUT WHOSE SPIRIT THE WORLD COULD NEVER CHAIN. THE COURAGE WHICH MAKES FOR PROGRESS, THE COURAGE OF THE INVENTOR, SCIENTIST, DISCOVERER, OR THINKER WHO SEES THE NEEDS OF THE FUTURE AND WORKS FOR THEIR FULFILLMENT, IS THE COURAGE ON WHICH ACHIEVEMENT IS FOUNDED. THIS IS THE COURAGE THAT DENIES VENERATION TO THE OBSOLETE, THAT HEWS AHEAD WHILE COMPLACENCE LAGS, THAT WILL NOT DROWN TALENT IN TIMIDITY, THAT FEARS NEITHER CRITICISM NOR DOUBT, THAT IS UNMINDFUL OF RIDICULE. THIS COURAGE OF BELIEF IN ONE'S OWN PLANS AND IN THE ABILITY TO CARRY THEM FORWARD, THIS IS THE COURAGE OF DETERMINATION.

—*Ayer.*

ALCOHOLISM AND MORPHINISM AS COMPLICATING FACTORS IN ANESTHESIA . THE SURGERY OF ELECTION . PATHOLOGICAL CHANGES DUE TO CHRONIC ALCOHOLISM . SPINAL PUNCTURE . DEHYDRATION . PRELIMINARY MEDICATION . ANESTHETIC EMERGENCIES . TECHNICS OF ANESTHESIA FOR ALCOHOLICS . POSTOPERATIVE RECOVERY . HANDLING DRUG ADDICTS . THREE TYPES OF HABITUES PRESENTING . USING PERIOD OF SOMNOLENCE .

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COMPLICATING FACTORS of anesthesia are of continual interest. It is scarcely to be expected that prohibition will end alcoholism immediately or that the Harrison Anti-Narcotic Law will abolish drug addiction. In this connection F. H. McMechan, of Avon Lake, Ohio, discussed alcoholism and morphinism as complicating factors of anesthesia, during the Fourth Annual Meeting of the American Association of Anesthetists, at Detroit, and his observations were later published in the Anesthesia Supplement, and then further elaborated in The Nurse, August, 1917

Alcoholism and morphinism are two rather prevalent annoyances with which the surgical departments of all hospitals have to contend. They not only involve an extra hazard of life, but often jeopardize the satisfactory conduct of anesthesia and the operative procedure and not infrequently precipitate untoward incidents into recoveries that otherwise should be uneventful.

These conditions are no respecters of sex or social status and are encountered among the dregs of the humblest dispensaries as well as the aristocratic clienteles of the most exclusive surgical clinics. Both can be properly dealt with if previously recognized. Concealment, whether through ignorance or design, always proves disastrous.

In these days of propaganda for reform in everything, it is essential to emphasize the fact that alcoholics and drug addicts, coming to operation under anesthesia, must be accepted as such and handled accordingly. Misdirected efforts at reformation invariably cause more danger and distress than the original complications involved.

In the routine surgery of alcoholics or drug addicts it is imperative to allow them their daily requirement of liquor or opiate. Such consideration will not only conserve what remnants of vital forces these derelicts still possess, but it will also render them manageable. On the contrary, efforts at withdrawal or reduction below the minimum daily requirements of alcoholic saturation or drug balance will result either in disconcerting nervous exaltation or imperiling physical collapse.

THE SURGERY OF ELECTION.

IN THE SURGERY of election, preliminary withdrawal or reduction may be tried, provided no operative procedure is attempted until the alcoholic or the drug addict has reestablished a fairly normal condition. Such preliminary treatment is not a matter of a few days of alkaloidal medication and violent purging, as is advocated by some, but a long, tedious, restorative process, involving a complete reversal of metabolism, a resumption of functional activities, and the elimination and control of psychopathic factors. This chapter on the cure of the alcoholic and the drug addict remains to be written. Until this has been done, the surgeon, anesthetist, and nurse must accept these extrahazardous risks as such and give them the full benefit of every possible measure of conservation.

While alcoholics and drug addicts are both difficult subjects to handle surgically, the method of managing each and the respective dangers involved are somewhat different.

In many respects the effects of alcoholism on the tissues and organs resemble the results of strangulation. Even the casual observer realizes that the alcoholic is continuously underoxygenated, if not persistently cyanosed. The alcoholic is so hazardous a surgical and anesthetic risk because alcoholism affects all the protective forces and eliminative resources of the body.

PATHOLOGICAL CHANGES DUE TO CHRONIC ALCOHOLISM.

CHRONIC ALCOHOLISM causes the following pathology: (1) A persistent form of general acidosis; (2) arteriosclerosis and cardiac hypertrophy; (3) increased intracranial pressure and edema of the brain; (4) cirrhosis or fatty degeneration of the liver; (5) intermittent nephritis; (6) cortical degeneration of the adrenal glands; and (7) increased susceptibility to postoperative infection.

In the preparatory régime of alcoholics for any operation under general anesthesia it seems needless to reiterate the efficacy of the several measures for the control of acidosis. Carbohydrate feeding with the addition of fruit juices and alkaline waters is always indicated. For toxemias associated with alcoholism, glucose solution should be given by rectum in conjunction with Fischer's soda solution intravenously in the presence of edema or nephritis.

Delirium tremens or alcoholic coma may precede or follow operations on alcoholics. Following the enforcement of the Harrison narcotic law, many drug users turned to alcohol as a substitute for morphin. A notable increase in the number of patients suffering from delirium tremens has been the result, and this fact has enabled Nuzum, Le Count, and Hogan to pursue some very brilliant pathological and clinical studies in this complication.

Among the histologic changes occurring in the brains of chronic alcoholics, Le Count includes vacuolization and high-grade degeneration of the nerve cells with atrophy and shriveling, fatty infiltration of the medullary substance, dissolution of the chromatin structure, inflammatory infiltration of the pia, and internal hydrocephalus. In delirium tremens, in addition to these changes, an edema of the leptomeninges is frequently present and most marked when coma or semicoma has preceded death for some time. Such a patient is often referred to as having a "wet brain." This edema is characterized by a distention of the meshes of the pia-arachnoid, whereas the brain substance itself may not contain a relatively marked amount of fluid.

In delirium tremens there are probably at least three factors concerned in absorption of water by the brain colloids. First, alcoholism has a detrimental influence on the brain as evidenced by atrophy, described by Lissauer, which occurs in the cortex of chronic alcoholics. This may lead to impairment of the circulation and asphyxia. Secondly, cardiac weakness plays a rôle in chronic alcoholism. When of sufficient degree, cardiac weakness results in a deficient blood supply to the brain and thus cerebral respiration is still further interfered with. Finally, alcohol is a narcotic and anesthetic. Like other narcotics, it may produce a cell asphyxia directly. Alcohol and its derivatives have been demonstrated in the spinal fluid of alcoholics by Schottmueller and Schumm; according to Delorme, twenty-four hours are required for their elimination from the spinal fluid following a debauch.

SPINAL PUNCTURE.

THESE LATTER CONSIDERATIONS probably account for the clinical value and success of S. P. Kramer's method of spinal puncture and withdrawal of fluid, under sphygmomanometric control, in almost immediately relieving the symptoms of acute delirium tremens or alcoholic coma. Steinbach has withdrawn as much as one hundred mils of the spinal fluid in alcoholic "wet brain" without any ill effects.

After experimental work with various salts that have the power of dehydrating edematous tissues, Hogan has devised a mixture of sodium bromid, sodium chlorid, and sodium bicarbonate that can be used in large quantities, intravenously, without producing the toxic effect of bromides as ordinarly given in large doses. As the severe types of alcoholics also suffer from a starvation acidosis, glucose in high concentration is used by Hogan intravenously. This not only furnishes an available carbohydrate, readily utilized by the body, but in 30 per cent. concentration produces marked dehydrating effects on the central nervous system.

DEHYDRATION.

PARADOXICAL AS IT may seem, Hogan has shown that, despite the fact that the volume of the circulating blood is increased in these conditions of high blood-pressure, if a proper solution is used intravenously, it is possible to dehydrate the blood and other tissues of the body. If the amount of salt in combination with the water injected is in excess of the normal concentration, it will diffuse into the tissues of the body and liberate water from them. This dehydration causes shrinking of the blood colloids and results in the lowering of the blood-pressure. Both the alkaline and glucose solutions are so prepared that they do not produce hemolysis, and the association of the chlorin with the bromin ions prevents the toxic effect of the latter. As these solutions give promise of coming into routine use, Hogan's directions for their preparation are given in detail.

In the preparation of the solutions 5.8 grams of chemically pure sodium chlorid and 8.4 grams of chemically pure sodium bicarbonate are boiled in 120 mils of *freshly* distilled water (stale distilled water causes chills) or tap water filtered through a Berkefeld filter. The solution is filtered through paper and then placed in a flask and reboiled. In addition, 10.2 grams of chemically pure sodium bromid are boiled in 30 mils of distilled water, filtered, and reboiled. These solutions may be kept ready for use and when needed are added to 850 mils of freshly distilled water or tap water that has been boiled and filtered. This mixture is heated to about 110° F. and is then ready for use.

The glucose solution is prepared as follows: 80 grams of glucose are added to 250 mils of distilled water and boiled; to this is added 0.25 gram of blood charcoal. This is allowed to stand for twenty-four hours, then filtered into a clean flask and reboiled, when it is ready for use.

Both of these solutions must be given very slowly, from twenty to thirty minutes being consumed in administering 1250 mils intravenously. A small percolator, such as is used in giving salvarsan, with rubber tubing and needle attached, all properly sterilized, is the only apparatus that is needed.

Hogan's method of combating acidosis, delirium, coma, and edema is available for use in the preoperative and postoperative régime in the presence of these complications.

PRELIMINARY MEDICATION.

IN ALCOHOLICS CARE must be exercised in preceding operations under anesthesia with hypnotics. While chloral, morphin, hyoscin, and other drugs are available for this purpose, they must be used with discretion. Apomorphin is preferable to morphin and paraldehyde when given by rectum is more satisfactory and less dangerous than chloral. Owing to the effects of alcoholism on the adrenals and the brain, pituitrin is a veritable sheet anchor in all emergencies involving embarrassment of the circulatory system. Pituitrin replaces ergot and adrenalin, providing the advantages of both without the disadvantages of either.

Concealment of the addiction to morphin or alcohol may result in insufficiency or overdosage of the preliminary medication; hence the necessity for accurate knowledge in the premises. By dividing the dosage of the preliminary medication and giving the first dose two hours before the contemplated operation, the nurse in attendance can gauge the patient's reaction to such an extent that the second dose may be given or withheld according to indications.

ANESTHETIC EMERGENCIES.

AS ALCOHOL BELONGS TO the group of hydrocarbon narcotics; the alcoholic coming to operation is a patient already partially under the influence of an anesthetic. Unfortunately, the excitement stage of alcoholic narcosis is far more prolonged than that of any other anesthetic and the effort to administer another anesthetic not only exacerbates the pugnaciousness of these unmanageable patients, but almost invariably precipitates the following symptom-complex: (1) An ascending degree of cyanosis; (2) an increase of excitation; (3) tonic or clonic spasms of the musculature with embarrassment of respiration, asphyxia, and abrupt cardiac arrest; *or* (4) overventilation of the lungs followed by (5) acapnia, with pallor, apnea, and gradual cardiac exhaustion.

The fact that alcoholics are under and out of anesthesia with disconcerting rapidity makes chloroform an especially dangerous anesthetic for these extrahazardous risks, because its administration invites the incidence of cardiac fibrillation, and it is a fact that the high percentage of mortality from chloroform anesthesia has been considerably influenced by the large number of alcoholics who have been injudiciously subjected to this method of anesthesia.

While experts can handle alcoholics under nitrous oxid-oxygen anesthesia, with or without supplemental etherization, the method is somewhat difficult as a routine and the margin of safety rather narrow. It is a problem to avoid imperiling cyanosis in alcoholics under nitrous oxid-oxygen anesthesia and this cyanosis, aside from its untoward results, may terminate abruptly in profound asphyxia and cardiac dilatation during the stage of excitement and struggling.

TECHNICS OF ANESTHESIA FOR ALCOHOLICS.

TWO TECHNICS OF anesthesia offer a safe and efficient method of surgical narcosis for alcoholics: (1) The essence of orange-ethyl chlorid-C_1E_5 mixture (chloroform one part, ether five parts), by the semiopen, drop method with concomitant oxygenation, and (2) ether-oil colonic anesthesia (Gwathmey) with the preliminary use of paraldehyde.

The former is satisfactory because the essence of orange obtunds the inconvenient air-way reflexes, so conspicuous in alcoholics, the ethyl chlorid obviates cyanosis and rapidly controls excitement, while the C_1E_5 mixture gives all the advantages of these agents used separately without any of their respective disadvantages. Concomitant oxygenation enables the anesthetist to prevent mild grades of persistent cyanosis and to induce and maintain, with the least danger, a deeper and more satisfactory plane of surgical anesthesia. The semiopen method of administration gives just sufficient rebreathing to conserve the requisite carbon dioxid tension to prevent acapnia as a result of overventilation of the lungs, should struggling and excitement supervene.

When combativeness does occur the attending nurse should merely restrain the patient and not make her movements sufficiently emphatic to leave the excited patient under the impression that he is being fought with.

Ether-oil colonic anesthesia is a satisfactory routine method, especially in obese and plethoric types of patients. The minimal effect upon the brain and kidneys of this method and its freedom from respiratory reflexes or embarrassment make it a technic of exceptional value in handling alcoholics.

POSTOPERATIVE RECOVERY.

POSTOPERATIVELY, ALCOHOLICS recover from anesthesia by crisis, and, while the majority become quite rational almost immediately after their return to bed, some few are very excitable and combative and require the strict supervision of an attending nurse to see that they do nothing to jeopardize the success of the surgical operation that has just been performed. Alcoholics are subject to untoward complications during convalescence, infection, pneumonia, delirium tremens, coma, and kidney insufficiency, and these complications should be anticipated by the use of the prophylactic measures indicated in the preparatory régime. The carbohydrate diet should be pushed, fruit juices and alkaline waters administered freely, the Hogan solutions given at the first indication of trouble, and spinal puncture utilized if necessary. If these measures will spare nurses the care of patients with postoperative delirium tremens, it is certainly worth while to put them into routine use.

Provided the narcotic addict's drug balance is painstakingly conserved, he will withstand anesthesia and operation with impunity. Bishop, who has contended with this problem at Bellevue Hospital for years, has formulated the following dictum: "The reduction of a drug of addiction below the amount of body need robs the addict of his most valuable asset in securing and maintaining recuperative powers."

HANDLING DRUG ADDICTS.

DRUG ADDICTS PRESENTING for operation are of several types, each of which requires a somewhat different method of handling: (1) Those addicts who, except for the habitual use of opiates and a psychopathic taint, are otherwise practically normal; (2) those addicts who use opiates to control the pain or symptoms of certain diseases, such as malignancy or diabetes; and (3) those addicts in whom the use of opiates is merely one phase of an entire moral and physical degeneration.

The first react to operations under anesthesia in almost the same manner as alcoholics. In handling them it is important to make their drug addiction serve the useful purpose of preliminary medication, although care must be exercised that concealment of addiction does not result in overdosage. Each case should be studied in order to so arrange the dose of the opiate that the period of somnolence will coincide with the induction stage of anesthesia and the beginning of the operation. If induction is attempted during the excitement period of the narcotic, drug addicts are quite as unmanageable as alcoholics. In this connection, Bishop's policy of giving the addict his daily requirement of opiate in the least number of doses compatible with comfort is well worth remembering.

In the second class of addicts every effort should be made, unless an emergency exists, to put the addict into approximately normal condition before operating. It is interesting to note that in the largest cancer hospital in London, acetylsalicylic acid has almost entirely replaced morphin for the relief of pain to the benefit of all concerned, surgeon, anesthetist, patient, and perhaps most of all, the nurse. The "blue devils" of melancholia have been banished by this simple substitution and, if anything, the pain of malignancy has been far better controlled than by opiates. These patients and the derelicts in whom the toxemia of infections and the ravages of malignancy have depleted the body of all the forces of resistance and recuperation, if operated on, should be given the benefit of nitrous oxid-oxygen anesthesia. These patients must be persistently over-oxygenated, as their tendency is toward exhaustion of the circulatory and respiratory system on account of the depletion of tissue respiration due to acidosis. If these addicts show a breath-holding test of less than thirty to forty seconds, they should be considered unfit risks for operations under general anesthesia until their condition has been improved.

It may be stated as a working principle that alcoholics and drug addicts should be operated on under local or conductive anesthesia, except in the presence of infection, and only under general anesthesia when no other method of narcosis suffices for the required operative procedure.

When alcoholics and drug addicts are operated on under general anesthesia, they shoud have all the advantages of a thorough preoperative régime, a cautious operation and anesthesia, and a carefully supervised recovery.

Alcoholism and morphinism are two important complicating factors in the morbidity of surgery that still defy the skill of the surgeon, the precautions of the anesthetist, and the solicitude of the nurse. Their elimination is a reform devoutly to be wished.

HEART LESIONS IN ANESTHESIA . RISK OF VARIOUS TYPES . PRECAUTIONARY MEASURES . PREOPERATIVE DIET AND SEDATIVES . IMPORTANCE OF POSITION . SELECTION OF THE ANESTHETIC . POSTOPERATIVE PRECAUTIONS . THE OPERATIVE RISK IN CARDIAC DISEASE . THE CLASSIFICATION OF CARDIOPATHS . DETERMINATION OF RISK . GROUPS STUDIED—AURICULAR FIBRILLATION, EXOPHTHALMIC GOITER, THYROTOXIC ADENOMAS, AURICULAR FLUTTER, PARTIAL AND COMPLETE HEART BLOCK, INTRAVENTRICULAR BLOCK, MITRAL STENOSIS AND AORTIC LESIONS . THE VALUE OF THE OPEN DROP-METHOD OF ETHERIZATION . SUMMARY AND CONCLUSIONS . TENDENCY TO REQUIRE TOO GREAT A MARGIN OF CARDIAC SAFETY .

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HEART LESIONS as complicating factors of operations under anesthesia have lately been receiving the attention they deserve. F. L. Richardson,[1] of Boston, recently presented his views on this subject before the combined meeting of the Sections of Medicine and Surgery of the Massachusetts Medical Society, June 19, 1918. The general public, and to a lesser degree, the medical profession, have a fear of the grave results of anesthesia on patients with heart lesions.

While it is true that patients with heart lesions die while under the effect of an anesthetic, it is much more often due to the operative procedure than to the anesthetic, provided the anesthetic has been wisely selected and properly administered. I am afraid that the anesthetic and the heart have been blamed in certain unfortunate cases, whereas the operation or the manner in which the anesthetic has been administered are the real factors in the case. Please do not understand me as believing that cases with heart lesions offer no greater risks than healthy individuals, for this is obviously not true, but usually they are not as serious risks as they are believed to be. Snow, in his classic on anesthesia, says: "*If a patient is able to undergo an operation, he will not be an impossible subject for an anesthetic.*" After the lapse of almost 70 years there is no reason to change this statement.

RISKS OF VARIOUS TYPES OF HEART LESIONS.

VALVULAR HEART LESIONS that are perfectly compensated and with a reasonable margin of safety offer very little danger from the anesthesia. When, however, compensation is broken or the margin of safety is very narrow the danger of the anesthesia increases markedly. In general if the heart lesion does not interfere with the ordinary affairs of life it will not interfere with the taking of an anesthetic.

Lesions of the aortic valve are more serious than lesions of the mitral valve, and stenosis is more serious than simple regurgitation. Endocarditis and degeneration of the myocardium offer much more serious risks than chronic valvular disease, and I have a great fear of angina pectoris as a complicating factor.

1. Richardson, F. L.: Heart Lesions in Anesthesia. Boston Medical & Surgical Journal, October 10, 1918, Vol. clxxix, No. 15, 470-473.

PRECAUTIONARY MEASURES.

IN MY CARE OF patients with serious disease of the heart of whatever nature it may be, there is one fundamental principle about which all our treatment should center—maintain the blood-pressure at a point as near the level which is normal for that individual as possible. One should keep this in mind in the preoperative treatment, the operative procedure, the selection and administration of the anesthetic, and in the postoperative care.

Wherever possible, patients with cardiac lesions should be put in bed, if they are not already there, and watched for a number of days without any change in their medication or food. The patient should be in about the position that he will have to occupy after the operation. This gives one an idea of how the patient should behave under conditions that would be ideal during convalescence—in other words, it gives us a *base line*. Blood-pressure should be taken at least once a day and I wish particularly to emphasize the importance of the diastolic pressure. In this period one has an opportunity of observing the effect of the postoperative position on the condition of the lungs.

PREOPERATIVE DIET AND SEDATIVES.

THE CHARACTER OF the diet before operation should be changed as little as possible from the normal. If the operation is to be at all protracted it is advisable to reduce the fats and increase the carbohydrates. I feel that the giving of 10 to 20 grains of sodium bicarbonate two hours before the operation is of some advantage. Cathartics should never be given unless the patient is in the habit of taking them.

When the time comes for the operation the patient should be carried to the anesthetizing room and never be allowed to walk or to exert himself in the least. Quiet, but not absolute stillness, should be observed as soon as the anesthetic is started. Many of these heart cases are high-strung and nervous, and fright is certainly a factor that should be reduced to a minimum, even though it is not possible to eliminate it.

Morphin and atropin should usually be given as preliminary medication and it is necessary that they be given sufficiently early to allow of their maximum action before the anesthetic is started.

IMPORTANCE OF PATIENT'S POSITION.

THE PATIENT SHOULD be placed on the operating table in a comfortable position. If the patient has been in the habit of sleeping with 3 or 4 pillows there is a reason for it. The patient has discovered the position in which he sleeps most comfortably and no preconceived ideas of ours should interfere with his comfort. There is a more potent reason for this than the simple giving way to the patient's whim. If one wishes to have a smooth induction it is necessary to have the patient physically as well as mentally comfortable. If this usual sleeping position of the patient is not compatible with the operative procedure the position should be changed very gradually after the patient is fully anesthetized, for any sudden change may cause a serious interference with breathing or heart action. It is particularly necessary to change the position gradually when the Trendelenburg position is required, and the surgeon should be willing to dispense with this position in case of serious interference with the cardiac or pulmonary function, even if very inconvenient for him.

SELECTION OF THE ANESTHETIC.

WITH REGARD TO the selection of the anesthetic, if the operation can be performed *without pain* under *local anesthesia* and the patient is not too apprehensive, this offers by far the least risk. It must be remembered that many operations that can be performed under local anesthesia without pain are not without certain sensations, namely, the feeling of pressure and traction, which may be interpreted as pain by a nervous and apprehensive patient. The fear in these instances may be a greater element of danger than the taking of a general anesthetic would be. *Fear and pain will both affect blood-pressure just as surely as ether or nitrous oxid, and the exhaustion following a long operation under local anesthesia is a factor that must be given proper consideration.*

Spinal anesthesia should never be given to patients in whom cardiac compensation is broken or in whom the margin of safety is narrow. It is a good rule not to use this form of anesthesia in any patient who will not stand a temporary fall in blood-pressure of 50 per cent. *Patients with arteriosclerosis stand spinal anesthesia quite well and they usually have the sluggish nervous system well suited to operations on a conscious patient.* Here again one should consider the nature of the operation, for it is generally conceded that spinal anesthesia is not safe for operations above the umbilicus.

Paravertebral anesthesia would offer many advantages over local or spinal anesthesia if it were not for the preliminary dose of scopolamin, a drug that is too much of a depressant and too uncertain in its action to be used in cases with serious heart lesions.

Gas-oxygen, which has been heralded by its enthusiastic supporters as the safest of all general anesthetics, is in reality far from safe in many cases, especially in cases of broken compensation or angina pectoris. I believe that this danger is probably due to the rise in blood-pressure that is usually present to a certain degree and may become quite extreme if rebreathing is excessive or where cyanosis is allowed. Operations requiring little or no muscular relaxation and of short duration may in many cases be done with less disturbance to the patient under gas-oxygen than under any other form of anesthesia, but where the operation is of long duration, and especially if muscular relaxation is required, this form of anesthesia offers certain grave dangers. It must be remembered that great changes in the condition of the patient may occur with alarming rapidity and with little or no warning under this anesthetic This may be due to the rapidity of the action of nitrous oxid or to the nature of the surgical procedure. Whatever the cause of these changes, they are none the less alarming and dangerous.

One of the advantages claimed by the enthusiastic supporters of gas-oxygen is the rapidity with which the patients regain consciousness after the operation is completed. This is certainly dramatic; but is it a real advantage? If the operation is one that will be followed by much pain the patient regains full consciousness at a time when this pain is at its height, and this may in part counterbalance the advantages of this form of anesthesia. The pain is much less if the technic of *anocithesia* is followed out, but there is the loss of some time in doing the local anesthesia.

Another advantage claimed for gas-oxygen is the lack of nausea and vomiting,—matters of considerable importance, especially in heart cases. In my hands I believe that almost as many patients vomit after prolonged gas-oxygen anesthesia as after ether, but the duration and severity of the vomiting are much less. This is a real advantage.

Ether, like gas-oxygen, may raise the blood-pressure; but to a less extent, if properly given. Ether is a cardiac stimulant of more even action. *Its use is usually followed by a period of deeper and longer depression than gas-oxygen, and it is this period of depression, following the administration of ether, that one should fear rather than the actual operative period. There are hardly any patients with heart lesions who will not go through the operative period with an ether anesthesia, but some of these patients will not survive this period of depression following.* To a certain extent the length and severity of this period of depression are governed by the depth of the anesthesia and the length of the operation.

Chloroform, unlike gas-oxygen and ether, lowers the blood-pressure. Chloroform has certain advantages over ether. It is not unpleasant to take and it is somewhat quicker in its action. There are three periods of danger in its use. (1) Probably the highest percentage of fatalities in patients with heart lesions occurs during the induction, where with little or no warning the heart action stops. When this occurs it is not often possible to resuscitate. (2) The second period is during the maintenance, and the danger here is much less than in either the first or the third periods. (3) The third period is from 3 to 5 days after the operation and is due to the toxic action of the chloroform on certain organs, notably the liver, adrenals and heart muscle. Unfortunately, this action has not been recognized until quite recently; deaths occurring during this period being attributed to other factors than the anesthetic. I do not feel that we are as yet in a position to estimate the seriousness of this danger period, though I believe that it is of real importance.

Theoretically, it would seem as if we should be able to combine ether with chloroform in such a way that there would be little or no change in the blood-pressure. This has been tried for many years, notably by the English in the various *A. C. E. mixtures*. A mixture of ethyl chlorid, chloroform and ether has been commercially exploited and largely used in America, but I believe it is now falling into disuse, as are the *A. C. E. mixtures* of the English. These various mixtures of chloroform and ether are much like the *standing orders* for the use of various drugs at some of the hospitals. They fit some cases admirably but are quite unsuited to other cases. The addition of a little chloroform to the mask is very useful when inducing anesthesia with ether, but the mixture should be made on the mask as indicated and not according to any preconceived formula. A very little chloroform dropped on the mask with the ether shortens the period of induction and reduces the amount of excitement. It also diminishes the rise in blood-pressure that is seen with a straight ether induction. Chloroform will also quiet the cough of a patient with bronchitis, but it is very rarely desirable to continue its use after the period of deep anesthesia has been reached.

POSTOPERATIVE PRECAUTIONS.

DURING THE POSTOPERATIVE period it is more important in these heart cases than in the ordinary cases to prevent any unnecessary overload and to maintain the nourishment of the patient at a high level. Overload may come from various causes; among them the kidneys and intestines play a large part and it is necessary to keep them functioning properly. Water should be given freely. When for any reason it cannot be given by mouth it must be given either by rectum or subpectorally, and in rare instances intravenously. It is advisable to begin food by mouth very early, and when I speak of food I do not mean beef tea and chicken broth; I mean food of real caloric value. When a patient cannot take food by mouth within 18 hours it is advisable to give nourishment by rectum. Glucose may be given by rectum in 5 to 10 per cent. strength and liquid peptonoid may be added to this if desired or wherever rectal feeding has to be given over a protracted period.

The urine should be carefully watched for acetone, and to those cases showing a considerable rise, sodium bicarbonate should be given in small and repeated doses. Of the so-called heart stimulants, most are absolutely useless. The judicious use of morphin must not be forgotten. More heart cases require rest after the operative period than require stimulation.

In conclusion, I wish to emphasize the importance of attention to the careful and detailed treatment of heart cases during the preoperative and postoperative periods as well as during the operation and anesthesia.

SINCE THE PUBLICATION of a previous article on the operative risk in cardiac disease,[1] the number of operative cases complicated by heart disease examined in the Mayo Clinic has markedly increased, and F. A. Willius, of Rochester, Minn., presented these further observations before the Sixth Annual Meeting of the American Association of Anesthetists, Chicago, Ill., June 10-11, 1918.[2]

Other groups of cardiopaths have been added to the classification, and also they have been included in this report. The greatest difficulty encountered was the classification of cardiopaths into groups of similar patients for comparative study and while the grouping employed is not beyond criticism, it gives a working basis for risk determination. A paper of this sort necessitates the incorporation of statistical data and the presentation of such data is apt to be dominated by monotomy. A search of medical literature revealed only scattered reports of operative risk in cardiac disease.

This report does not include all the cases of heart disease coming to operation in the Clinic but it does include those in which electrocardiographic examinations have been made since August, 1914. The advent of the electrocardiograph has been very helpful in the classification of cases by permitting the recognition of otherwise obscure conditions.

Experience has shown that the best index of operative risk in heart disease is the patient's ability to stand physical strain, supplemented, of course, by thorough history taking and thorough physical examination. Patients whose hearts allow them to go about in comfort, or those in whom this can be effected by medical treatment, are generally considered safe for operation.

In heart disease due to focal infection, such gratifying results are frequently seen following the removal of the focus, that the added risk seems justified. Another group of cases often shows marked cardiac improvement sufficient fully to justify the risk, namely, goiter, uterine fibroids and prostatic hypertrophy. Malignancy complicated by heart disease is generally considered operable if a fair chance for recovery is offered, and such cases often require palliative operations. In very few instances in which there has been urgent need of operation has it been refused on account of the cardiac condition, though in many instances, operation has only been undertaken after preliminary medical therapy.

DETERMINATION OF OPERATIVE RISK.

IN EVERY CASE the decision is based on several factors: (1) The immediate operative risk, (2) the probable improvement of the heart following 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 or not the operative relief will justify the added risk. Experience in general has justified the taking of risks in cases demanding surgical intervention.

It is impossible to classify cases on a basis of valvular disease alone because the true index of cardiac efficiency is myocardial quality and this varies greatly in similar disease conditions. A classification based on cardiac reserve alone is also impossible because we have no accurate means of determining this factor and clinical impressions are variable.

GROUPS OF CASES STUDIED.

SIX GROUPS OF cases have been studied. These are generally recognized as bad risks, or the worst risks, if angina pectoris and aneurysm are excepted. The groups are: (1) Auricular fibrillation, (2) auricular flutter, (3) impaired auriculo-ventricular conduction, (4) im-

1. Blackford, J. M., Willius, F. A., and Haines, S. B.: Operative Risk in Cardiac Disease. Jour. Amer. Med. Asso., 1917, Vol. lxix, 2011-2014.

2. Willius, F. A.: The Operative Risk in Cardiac Disease. Amer. Jour. Surgery, Anesthesia Supplement, Vol. xxxii, No. 10, October 1918, 121-124.

paired intraventricular conduction (arborization block), (5) mitral stenosis, and (6) aortic lesions including valvular disease, aortitis and dilatation (not aneurysmal.)

Auricular Fibrillation.—This disorder is now recognized as being due to incoördinate contraction of individual muscle bundles of the auricular wall. The auricles no longer contract, their walls dilated in diastole act as reservoirs in the general circulation. As the result of this disordered and inadequate stimulus production, the ventricular response is incoördinate and a pulse results which is usually totally arrhythmic. This condition may be chronic, intermittent or paroxysmal.

Exophthalmic Goiter.—Experience with exophthalmic goiter (hyperplastic toxic) has shown auricular fibrillation to be a frequent, disordered cardiac mechanism occurring in the course of the disease. Fibrillation occurs more frequently in the patient more than 40 years of age, and is often indicative of a relatively high degree of hyperthyroidism. *The myocardiums of older patients, of course, do not tolerate toxic insults well, and fibrillation is very prone to be a permanent condition.* The occurrence of this arrhythmia in young people usually evidences a high degree of hyperthyroidism for the hearts of younger patients usually stand strain well. In this group, 104 patients have been operated on with 4 deaths. One patient died following a Porter hot water injection and 3 following thyroidectomy. Of the latter, 2 died of hyperthyroidism and 1 of myocardial insufficiency on the second day after operation. Ten patients were under 30, twenty between 30 and 40 and seventy-four were more than 40 years of age. The operative mortality was 4 deaths in 104 cases (3.8 per cent.) which compares favorably with the normal operative mortality of 2.6 per cent.

Thyrotoxic Adenomas.—Many patients having adenomas (simple goiter) for a certain number of years, develop symptoms of thyroid intoxication. The onset of symptoms is frequently insidious and the initial subjective complaints, those of a failing myocardium. These patients are usually older, beyond 40 years of age, and as I have mentioned, the heart muscle does not tolerate toxic influences well. Added to this is an insidious onset. This group presents many cardiopaths. Experience has shown that such patients so often show striking cardiac improvement following thyroidectomy that the added risk seems fully justified. *All patients with fibrillation are, however, subjected to preliminary medical treatment which is continued after operation if the case demands it.* Thirty-six patients with fibrillation had thyroidectomies with one operative death, giving a mortality of 2.7 per cent. The normal operative mortality in this group is 2.8 per cent. *The favorable showing is owing largely to preoperative therapy and to the correlation between the surgical and medical services.*

Other Conditions.—There were 10 cases of fibrillation in patients less than 40 years of age and 20 in those more than 40 years of age, constituting a total of 30 cases in which operative measures were employed. The operations were as follows: 12 tonsillectomies, 4 excisions of epitheliomas (2 lower lip, 1 glands of the neck and 1 larynx), 1 excision of glands for diagnosis (sarcoma), 3 cholecystectomies and appendectomies, 3 gastro enterostomies (2 for ulcer and 1 for carcinomatous obstruction), 1 cholecystectomy, choledochotomy and appendectomy, 1 Talma-Morrison, 1 herniotomy, 1 cataract extraction, 1 suprapubic stab, 1 cauterization for urethral caruncle and 1 cystotomy and prostatectomy. There were 2 early deaths, 1 cardiac, following suprapubic stab, and 1 due to cholangitis following cholecystectomy.

Auricular Flutter.—This cardiac disorder is recognized as being due to rapid coördinate contractions of the auricles, stimulated by foci of irritation located in the auricular wall outside the normal pace-maker (sino-auricular node). The auricles contract at a rate of 200 to 380 per minute and the ventricles respond usually to one-half the auricular contractions, although any rhythm from a 1:1 association to a complete heart block may exist. The pulse is regular in one-half the reported cases and grossly irregular in the other half. The degree of block may vary from time to time and most patients are subject to paroxysmal *weak spells,* owing to sudden decrease in the degree of block which allows the ventricles to assume full auricular rate. The condition is usually chronic and may exist for years.

Four patients have been operated on, all included in the foregoing under fibrillation. These patients are of particular interest as apparently being the first proved cases of flutter coming to operation. A previous report[1] showed that these four patients were subjected to vigorous digitalis therapy, and rest until fibrillation was induced, and then operation was done.

Three of the patients had exophthalmic goiter, though one had a cholecystectomy and tonsillectomy in the Clinic and a thyroidectomy, later, elsewhere. One other patient had had tonsillectomy. All the patients with exophthalmic goiter resumed a normal rhythm after operation, and two had no further cardiac symptoms. The last patient on whom a tonsillectomy was performed, reports himself greatly improved. Thus far there has been no mortality.

Partial and Complete Heart Block.—One patient with complete block has had three operations in 11 years; appendectomy, radical amputation of the breast for carcinoma, and excision of recurring nodules of the skin. An electrocardiogram was taken before the last operation. The pulse was recorded as being unusually slow at the previous examinations. The patient is alive and quite well.

Ten patients showing delayed conduction between auricles and ventricles, that is, auriculoventricular intervals of 0.22 to 0.28 of a second, have been operated on as follows: 4 tonsillectomies, 1 double ligation of the superior thyroid vessels for exophthalmic goiter, 1 double ligation and subsequent thyroidectomy for exophthalmic goiter, 2 thyroidectomies for thyrotoxic adenomas, 1 cholecystectomy and 1 prostatectomy. Six were more than 40 years of age and 4 were under 40 years. The patient on whom prostatectomy was done died on the fourth day, presenting the cardio-vascular renal syndrome.

1. Blackford, J. M. and Willius, F. A.: Auricular Flutter. Arch. Int. Med., 1918, Vol. xxi, 147-165.

Intraventricular or Arborization Block.—This condition is due to impaired conduction of the cardiac impulse after its passage through the bifurcation of the auriculo-ventricular bundle and evidences disease of the main bundle branches and the subendocardial plexus. Oppenheimer and Rothschild[2] have emphasized the gravity of this condition and the early fatality which it often indicates. The electrocardiogram reveals a prolonged Q. R. S. interval and variations from slight notching to the unusual complexes which are ascribed to branch bundle defects. A striking observation in this group of cases is the uniformity with which the clinical findings are substantiated by the graphic records in revealing serious myocardial disease. Twenty patients have been operated on, 1 under 40 years of age and 13 more than 40 years, without any operative mortality. There were 8 tonsillectomies, 5 thyroidectomies (3 for exophthalmic goiter and 2 for thyrotoxic adenoma), 1 salpingectomy, 1 cholecystectomy and appendectomy, 2 chest aspirations, 2 gland excisions for diagnosis (1 malignant and 1 inflammatory) and 1 posterior gastro enterostomy for duodenal ulcer.

Mitral Stenosis.—Seventy-three cases of mitral stenosis are recorded in which operations were done. Twenty-five of the patients were under 40 years of age and 48 were more than 40 years. As previously stated, valvular disease alone cannot be satisfactorily grouped because of the difficulty in accurately classifying the degree of myocardial insufficiency. This mitral lesion is recognized as being serious owing to its tendency to progression, and therefore the cases have been included in this report. An attempt has been made to estimate by clinical impressions the degree of decompensation present, and, while obviously inaccurate, it is necessary in presenting the type of case represented in this study. The scale of 1 to 4 (minimum to maximum) has arbitrarily been used in denoting the degree of decompensation. The average in patients under 40 years of

2. Oppenheimer, B. S. and Rothschild, M. A.: Electrocardiographic Changes Associated with Myocardial Involvement. Jour. Amer. Med. Assn., 1917, Vol. lxix, 429.

age was 2, in those more than 40, 2+. Ten patients showed auricular fibrillation (*vide supra*) 9 of these were patients more than 40 years of age. The operations are as follows: 39 tonsillectomies, 17 thyroidectomies (10 for simple goiter, 4 for exophthalmic goiter, and 3 for thyrotoxic adenomas), and 4 of these patients had secondary operations including 2 tonsillectomies, 1 appendectomy and 1 double cataract extraction. There were one double ligation of the superior thyroid vessels for exophthalmic goiter, 4 appendectomies, 1 cholecystostomy, 4 cholecystectomies and appendectomies, 1 choledochtomy, cholecystectomy and appendectomy, 1 subtotal abdominal hysterectomy, 1 perineorrhaphy, 1 trachelorrhaphy, 1 tumor excision (benign), 1 inguinal herniotomy and 1 thoracic paracentesis. There was no immediate operative mortality but one patient died two weeks later of cholangitis following a choledochotomy, cholecystectomy and appendectomy. The mortality in this group is 1.3 per cent. It is impossible accurately to state the normal mortality in such a protean surgical list but 1.5 per cent. seems very conservative.

Aortic Lesions.—It has long been recognized that aortic disease needs no emphasis as regards its gravity. This group includes aortic valvular disease, aortitis and dilatation (not aneurysmal). Sixteen patients with aortic valvular disease have been operated on; 11 under 40 years of age and 5 more than 40 years. Six patients presented double aortic lesions, that is, insufficiency and stenosis, and 1 presented evidence of aortitis. One patient had aortic stenosis alone. These patients were all able to be up and about with relative comfort. Anginal pains were not elicited in a single instance. There were no operative deaths but 1 patient is reported dead from heart failure one year later (tonsillectomy). There were 12 tonsillectomies, 1 thyroidectomy for adenomas, 1 cholecystectomy, 1 double herniotomy and appendectomy, and 1 chest aspiration. Two patients with aortitis (not including the aforementioned case) were operated on; both were more than 40 years of age. There were one exploration (general abdominal carcinosis) and 1 tonsillectomy. The latter patient died a cardiac death three months later. Four patients with dilatations of the aorta (not aneurysmal) underwent surgical procedures. The clinical diagnoses in these cases were verified by the fluoroscope. Three of the patients were more than 40 years of age. There were 2 thyroidectomies for exophthalmic goiter, 1 tonsillectomy, and 1 cystotomy and herniotomy. There were no deaths.

SUMMARY.

1. The decision of operability in cardiac disease depends on 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.

2. 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.

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

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

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

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

ORAL HYGIENE IN RELATION TO ANESTHESIA, ANALGESIA AND THE ANESTHETIST . LACK OF PREOPERATIVE CARE . PREVALENCE OF BACTERIA IN PATIENTS' MOUTHS . TENDENCY TO REFORM . INFLUENCE OF TREATMENT . CASE REPORTS OF A VARIETY OF CONDITIONS . CONCLUSIONS .

BION R. EAST, D. D. S. BOARD OF HEALTH DETROIT, MICHIGAN.

SPEAKING BEFORE the Joint Session of the Interstate Association of Anesthetists and the National Dental Association, Bion R East, of Detroit, Michigan, detailed many points of interest regarding oral hygiene, as developed from the work of the Detroit Board of Health-Dental Department, in conjunction with the Research Laboratories of Parke, Davis and Co. Writing in the Anesthesia Supplement of the American Journal of Surgery, January, 1917, East observes that:

Oral hygiene may be defined as the science of keeping the mouth healthy. In this paper the writer proposes to define oral hygiene as any agent which may be used to prevent that condition which may arise either locally or systemically, which is the result of improper care of the mouth and teeth, either by the patient himself or herself, or due to improper, unskillful or criminally careless dental operations.

At the outset the author wishes to impress upon the members of this association that he claims no originality in any statement he may make in this paper other than that of the report of the cases presented. He simply wishes to impress upon the members of this association the importance of mouth hygiene and to show a few cases which have resulted from lack of hygienic conditions in the oral cavity. The author is going to assume that any condition which has, or may develop into, detrimental effects upon the whole body economy would lower the desirability of anesthetizing an individual. Any condition which lowers the body resistance in general certainly has a harmful effect upon a patient's toleration of an anesthetic or analgesic.

LACK OF PREOPERATIVE CARE.

A SEARCH OF MEDICAL and dental literature discloses an absolute lack of thought along the subject of this paper, therefore the author wishes this essay to serve simply as an introduction to what surely will prove to be an interesting field of investigation.

I wish first to call your attention to a series of tests which were made to reconfirm the fact that in a mouth receiving very little hygienic attention, one in which caries of the teeth are prevalent or other pathological conditions present, that bacteria were more prevalent and of greater virulency (Figure 1).

PREVALENCE OF BACTERIA IN PATIENTS' MOUTHS.

AN EXAMINATION OF these charts show the bacteria much more virulent where no care is given the mouth. Th great number of pneumococci present is of the greatest interest to the anesthetists.

In case No. 10, 45,000,000 pneumococci to the milligram were found present, of very high virulence; if for any reason this patient should be given a general anesthetic he surely would be a very favorable subject to develop postoperative pneumonia, if the patient should inhale saliva containing such virulent bacteria in such numbers as is present in his oral cavity. The disastrous effect of shock, which certainly follows the combination of general anesthesia, and the major operation, which made it necessary to give a general anesthetic, lowers the resistance of the body. Understand that I do not say the shock which follows a general anesthetic alone. Crile has demonstrated that the resistance is increased where nitrous oxid and oxygen is used as an anesthetic and the operation performed carefully in combination with local anesthesia, but many operations are not done carefully, many are of such a nature and magnitude that the patient must suffer shock and the body resistance lowered. I think you will agree that if the patient inhaled a saliva such as subject No. 10 is the possessor of, he might develop pneumonia, and the anesthetists or the agent used to anesthetize the patient receive full blame. It would be strange if it did not occur.

I am sure that if a careful examination of the

FIGURE 1.

Case No.	Condition of mouth.	Material taken from.	Baterial findings.	Number per mg.	Virulence.
1	Good	Gingival margins	Staph. Pneumo. Spirilums	7,000,000 5,000,000 1,000,000	Low
2	Good	Gingival margins	Staph. Pneumo. Unident.	7,000,000 6,500,000 5,000,000	Low
3	Good	Gingival margins	Staph. Strep. Pneumo. Unident.	9,000,000 2,000,000 7,500,000 5,000,000	Low
4	Brushed daily Cavities Canals putrid	Gingival margins	Staph. Pneumo. Strep. Unident.	10,000,000 25,000,000 5,000,000 10,000,000	Fairly high
5	Good. Blind abscess at apex of Bicuspid	Gingival margins	Staph. Strep. Unident. Pneumo.	15,000,000 6,000,000 2,000,000 5,000,000	Low
6	Very bad Mouth never cleaned	Gingival margins	Staph. Strep. Pneumo. Unident.	20,000,0000 7,000,000 15,000,000 100,000,000	Fairly high
7	Bad. Putrescent canals Never cleaned	Gingival margins	Staph. Strep. Pneumo. Unident.	15,000,000 3,000,000 30,000,000 50,000,000	High
8	Fair teeth Cleaned with handkerchief	Gingival margins	Pneumo. Staph. Strep. Unident.	6,000,000 10,000,000 8,000,000 110,000,000	Fairly low
9	Fairly clean Cavities	Gingival margins	Pneumo. Strep. Staph. Unident.	17,000,000 5,000,000 40,000,000 100,000,000	High
10	Very bad mouth Mass of decayed teeth	Gingival margins	Pneumo. Staph. Strep. Unident.	45,000,000 70,000,000 2,000,000 11,000,000	High
11	Never cleaned Fairly good	Gingival margins	Pneumo. Staph. Strep. Unident.	25,000,000 100,000,000 6,000,000 2,000,000	Very high

mouths of patients who have contracted post-operative pneumonia were made, a high percentage of them would be found to have unhygienic conditions present, due to caries, or pyorrhea, and that proper attention to overcome these con-

Figure 2.

ditions before the anesthetic was given would have eliminated the dreaded pneumonia.

Members of this association who have the opportunity to follow such cases in hospitals would find an interesting field of observation and confirm what many think to be true.

It has only been within the past year or so that the average physician could see anything in the mouth other than a tongue, when he made an oral examination. He considered the mouth simply as a convenient aperture through which he could examine the pharynx.

The teeth and gums seemed to have been considered as something entirely distinct from the whole body economy. The physicians and dentists must have labored under the impression that the teeth were created for the sole purpose of providing a suitable object upon which the dentist could exhibit, at times, his none-too-skilful workmanship.

Pyorrhea alveolaris was dismissed as an inconvenient but harmless disease, which was only cured by wholesale extraction. Pulps were des-

Figures 3, 4 and 5.

troyed and removed from teeth, and root canals allowed to go unfilled. Abscessed teeth were treated and supposed to be cured, but almost universal use of the dental radiograph has proven that many teeth, though comfortable, have rarefied areas at their apices.

Billings, Hartsell, Harris and others have proven that the infection here is the original cause of many systemic conditions, and when this focus was removed the systemic condition was relieved.

Figure 6.

Conditions such as these must react upon the patient when anesthetized.

TENDENCY TO REFORM.

I AM GLAD to state that conditions are rapidly changing; root canal filling and treatment are being undertaken seriously. Pyorrhea alveolaris is being treated and cured by skilful manipulation in conjunction with proper medical agents, of which emetine does not seem to be one.

Unsanitary bridge work is being removed and is being replaced by removable, hygienic substitutes.

I wish to exhibit a few cases showing the result of mouth infection and their primary cause.

Figure 2. The pulp has been destroyed in this lower molar, but the root canals are unfilled. Infection has destroyed the peridental membrane and alveolar process. The patient suffered no little pain and the permanent loss of the tooth. This is the result of improper root canal treatment on the part of the dentist.

Figure 3. Shows a case of pyorrhea referred to the board of health dental clinic by one of Detroit's hospital polyclinics, suffering with arthritis. Male, age 60, unable to dress or feed himself, unable to work.

Figure 4. Shows the degree he could close his hand at the beginning of treatment, which consisted of a thorough scaling of the teeth, the administration of a proper dosage of vaccine, and attention given to the elimination of waste products in the intestines. After four weeks he could close his hand as in Figure 5. The patient then resumed his work and was quite normal in every way.

Figure 6. A case from the dental department, Detroit Board of Health. Diagnosis, pyorrhea; infection, primary strep. pyogenes.; very virulent, but no rheumatism. Digestion very bad.

INFLUENCE OF TREATMENT.

VERY THOROUGH LOCAL treatment combined with emetine hypodermically and in tablet form. Before the emetine injections into the pockets, the recession shown was not present, but appeared twenty-four hours after the injection. Was it caused by emetine? Radiographs showed laterals gone, and they were extracted. The emetine treatment was now discontinued. After the emetine was entirely eliminated from the system, the teeth were then scaled and vaccines used. His digestive apparatus returned to normal; pus ceased, and he is now on the road to recovery.

Figure 7. Ulcer on the breast which defied treatment for two years. This ulcer disappeared

Figures 7, 8 and 9.

two weeks after the mouth infections were eliminated. Elimination consisted of simply extracting all diseased teeth, and the curettement of their sockets. Figure 8, shows the abscess healed. Figure 9, shows the condition of the mouth before treatment. Figure 10, baby at the time the mouth infections were broken up. Figure 11, one week later. Figure 12, six weeks later.

Figure 13. Rheumatic, unable to turn head; diagnosis, pyorrhea. Referred by Harper Hospital. Temperature, 101. *Treatment:* Scaling carefully and slowly done to avoid allowing the absorption of too much toxin at once. Vaccine given every five days. *Results:* Normal temperature in one week. Last traces of rheumatism gone in twenty-eight days, and no return in seven months.

In another rheumatic patient the gums were in bad condition and the joints badly swollen. The teeth were painful and resisted the usual treatment given in such cases, including vaccines. A filtered virus was then made from the pus, and an animal immunized against the virus. The complement was then obtained, diluted 1 to 1,000,

Figures 10, 11 and 12.

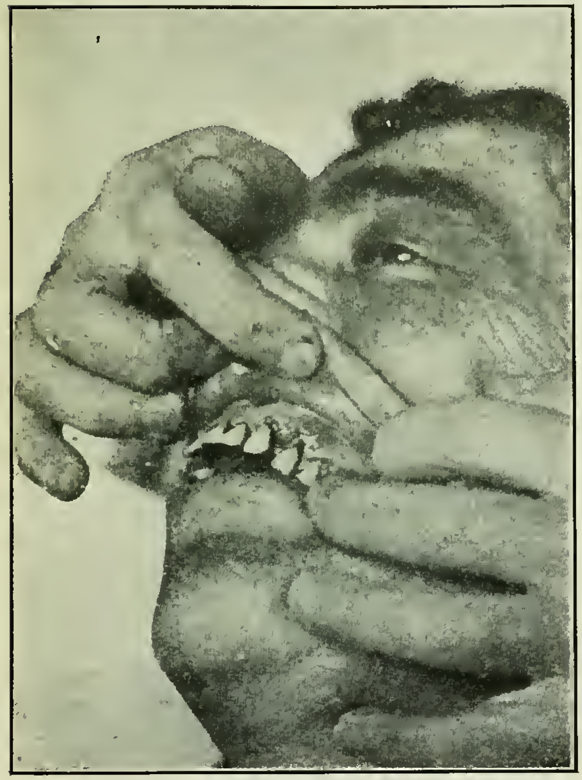

Figure 13.

Figure 14.

and combined with normal serum. This was placed in all the pus pockets. At the same time large doses of vaccine were used. A response came in one week. Two weeks, and all soreness left. Case still under treatment.

Figure 14. Tubercular patient; tubercle bacilli found in the pockets in large numbers. Local treatment only, with complement injected in the pus sockets was used. Cessation of the flow of pus, resulting from the treatment.

CONCLUSIONS.

WHAT IS TO be learned from these cases? First: That unhygienic conditions in the mouth have a very marked systemic effect. Second: That this may affect parts quite remote from the accepted locations. Third: We can infer that any conditions as potent as some mouth infections will be detrimental to anesthesia. Fourth: That patients with systemic infections should be given the benefits of oral hygiene and vaccines before and after operations under anesthesia and analgesia.

But what relation can oral hygiene bear to the anesthetist? First: Any agent which reacts upon the patient harmfully must indirectly affect the anesthetist and his work. Second: Anesthetists, being no more immune to pathological conditions in the mouth than any other human, may at the present time, and probably are, absorbing toxins and lowering their body resistance.

Let everyone who suspects improperly filled root canals, or ill-fitting bridge work in his or her mouth, have radiographs made; and if pathological conditions are found, have them removed before it is necessary to become the victim of a brother anesthetist.

THE PROPHYLACTIC USE OF PITUITRIN IN NOSE AND THROAT OPERATIONS UNDER GENERAL AND LOCAL ANESTHESIA . BLOOD PRESSURE . COAGULATION TIME . PRIMARY AND POSTOPERATIVE HEMORRHAGE . SCHEDULE OF OPERATIVE RESULTS . A SUMMARY OF EXPERIENCES AND CONCLUSIONS .

SAMUEL SALINGER, M. D. FRANCIS WILLARD HOSPITAL CHICAGO, ILLINOIS.

THE ACTION of extracts of the infundibular portion of the hypophyseal gland on the circulation has been well established through the investigations of Schaefer and Oliver,[1] Howell,[2] Houghton and Merrill,[3] Beck and O'Malley,[4] Wiggers,[5] Klotz[6] and others, and Samuel Salinger, of Chicago,[7] summarizes it as follows:

1. The blood pressure is raised from five to thirty-five millimeters within a few minutes through direct stimulation of the muscle coats of the arterioles.

2. This increase in blood pressure is prompt and the fall to normal, on the contrary, very gradual.

3. Due to the constriction of the arterioles the actual size of the various organs of the body is diminished with the rise in blood pressure. The kidneys are the only exception to this rule, as they become enlarged upon receiving the pituitary extract and the output of urine is increased.

4. The heart, according to the majority of investigators, is slowed down, probably due to direct depression of the heart muscle, and there is a diminution in the amplitude of the heart's excursions as demonstrated by Wiggers. Also there is a peculiar grouping of the heart beats in periods of two or more. All of these manifestations are most marked just after the crest in the blood pressure curve has been passed.

Based upon these facts the employment of pituitrin in connection with nasopharyngeal surgery was first given an impetus by Citelli,[8] who reported brilliant results in a number of turbinate and tonsil operations, where it had been used either as a prophylactic or for the control of postoperative hemorrhage. His clinical findings were generally corroborated by other operators with the single exception of Donelan,[9] who, having employed it in twenty-five cases, reported that he could see no difference in the amount of bleeding than in similar cases where no pituitrin had been used.

In 1915, Kahn and Gordon[10] reported their results in a series of 100 cases, mostly children, where they had used pituitrin as a prophylactic. They paid particular attention to the blood pressure and coagulation time of the blood taken before and after the administration of the agent. They found that the systolic pressure had been increased in 55.31 per cent. of the cases, reduced in 36 per cent. and unchanged in 8.5 per cent.

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8. Citelli: Zeitschr. f. Laryn. Rhinol. & Otology, 1913, Vol. vi.
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THE PROPHYLACTIC USE OF PITUITRIN IN NOSE AND THROAT OPERATIONS UNDER GENERAL AND LOCAL ANESTHESIA.

				BLOOD PRESSURE.			COAGULATION TIME.						
No	Name	Age	Operation	Before Injection	15 Min. After Injection	18 Hours Later	Before Injection	15 Min. After Injection	Primary Bleeding	Secondary Bleeding	Anesthesia Remarks	Remarks	No
1	T. S.	24	Tonsil	135 S. 100 D.	152 S. 118 D.	130 S. 90 D.	5′	2′	Venous requiring pressure	None	Cocain Quinin & Urea		1
2	D. S	22	Septum	134 S. 96 D.	142 S. 102 D.	115 S. 85 D.	4′ 15″	3′	None	None	Cocain		2
3	D. F.	26	Tonsils	120 S. 90 D.	130 S. 98 D.	125 S. 94 D.	5′ 50″	3′ 10″	Slight	None	Ether	Secondary operation	3
4	L. B.	21	Tonsils	115 S. 87 D.	120 S. 92 D.	120 S. 94 D.	3′	1′	Slight	None	Cocain Quinin & Urea	Secondary operation	4
5	A. H.	20	Tonsils	125 S. 96 D.	139 S. 98 D.	130 S. 95 D.	9′	4′	Moderate requiring pressure	None	Cocain Quinin & Urea		5
6	F. S.	28	Septum & Mid. Turb.	120 S. 85 D.	130 S. 92 D.	120 S. 90 D.	5′	3′ 30″	None	None	Cocain	Patient has T. B.	6
7	L. S.	4	Tonsils & Adenoids	85 S.	98 S.	90 S.	2′	1′ 15″	Slight	None	Ether		7
8	A. L.	30	Antrum	135 S. 100 D	142 S. 110 D.	138 S. 105 D.	4′ 30″	1′ 30″	None	None	Cocain	Secondary operation	8
9	M. B.	11	Tonsils & Adenoids	103 S. 72 D.	110 S. 90 D.	105 S. 80 D.	3′	2′ 35″	Slight	None	Ether		9
10	F. M.	29	Tonsils	115 S. 87 D.	128 S. 95 D.	120 S. 90 D.	6′ 30″	2′ 30″	Slight	None	Cocain Quinin & Urea		10
11	R. S.	21	Septum	100 S. 75 D.	125 S. 90 D.	118 S 82 D.	5′ 15″	2′	None	None	Cocain		11
12	M. S.	35	Tonsils	110 S. 82 D.	115 S. 90 D.	112 S. 83 D.	4′ 35″	1′ 30″	Slight	None	Cocain Quinin & Urea		12
13	C. T.	25	Tonsils	115 S. 88 D.	120 S. 90 D.	115 S. 88 D.	3′	1′	Slight	None	Cocain Quinin & Urea		13
14	E. W.	17	Tonsils	122 S. 88 D.	130 S. 96 D.	117 S. 86 D.	4′	2′ 30″	Moderate	None	Ether	Took the anesthetic poorly	14
15	A. W.	10	Tonsils & Adenoids	100 S. 80 D.	108 S. 84 D.	102 S. 80 D.	2′ 30″	1′ 10″	Slight	None	Ether		15
16	D. B.	22	Septum	132 S. 100 D.	138 S. 105 D.	130 S. 100 D.	3′ 30″	1′ 15″	None	None	Cocain		16
17	H. L.	28	Tonsils	130 S. 95 D.	140 S. 100 D.	132 S. 97 D.	6′	2′ 15″	Profuse venous: required pressure	None	Cocain Quinin & Ur.	Gagged violently: Oper. lengthy	17
18	R. Z.	17	Tonsils	100 S. 88 D.	108 S. 93 D.	100 S. 88 D.	3′	3′	Slight	None	Cocain Quinin & Urea		18
19	I. C.	29	Septum	115 S. 90 D.	123 S. 92 D.	120 S. 90 D.	3′	2′ 15″	Slight	None	Cocain		19
20	M. M.	19	Tonsils	120 S. 90 D.	122 S. 94 D.	104 S. 82 D.	6′ 30″	2′	Slight	None	Cocain Quinin & Urea		20
21	J. B.	19	Tonsils	115 S. 85 D.	120 S. 87 D.	120 S. 88 D.	5′	1′ 30″	Slight	None	Ether		21
22	M. L.	38	Tonsils	122 S. 90 D.	138 S. 97 D.	122 S 92 D	2′ 30″	1′	Slight	None	Cocain Quinin & Urea		22
23	M. B.	23	Tonsils	110 S. 82 D.	116 S. 88 D.	105 S. 80 D.	4′	2′ 30″	Slight	None	Cocain Quinin & Urea		23
24	G M.	34	Tonsils	130 S. 92 D.	142 S. 100 D.	135 S. 95 D.	5′	3′	Slight	None	Cocain Quinin & Urea		24
25	L. R.	24	Tonsils	120 S. 90 D.	126 S. 92 D.	118 S. 87 D	4′	1′ 15″	One spurter clamped	None	Cocain Quinin & Urea		25
26	O. G.	20	Tonsils	100 S. 75 D.	115 S. 80 D.	100 S. 75 D.	6′	1′ 45″	Moderate	None	Cocain Quinin & Urea		26
27	A. O.	27	Septum	118 S. 93 D.	130 S. 95 D.	120 S. 90D.	3′	1′	None	None	Cocain		27
28	D. M.	16	Tonsils	117 S. 82 D.	120 S. 85 D.	117 S. 80 D.	2′	1′	Slight	None	Ether		28
29	J. G.	15	Tonsils	117 S. 88 D.	123 S. 90 D.	120 S. 90 D.	4′	1′ 25″	Slight	None	Cocain Quinin & Urea		29
30	E. B.	15	Tonsils	108 S. 82 D.	110 S. 80 D.	112 S. 80 D	2′	1′ 30″	Slight	None	Ether		30
31	A. B.	38	Tonsils	132 S 95 D.	140 S. 98 D.	130 S. 90 D.	3′	2′	Slight	None	Cocain Quinin & Urea		31
32	A. F.	17	Tonsils	122 S. 88 D.	130 S. 92 D.	120 S. 90 D	4′ 20″	3′	Arterial: ligature applied	None	Ether		32
33	C. C.	27	Septum	120 S. 88 D.	130 S. 94 D.	124 S. 90 D.	2′	1′ 30″	None	None	Cocain		33
34	R. S.	30	Tonsils	142 S. 102 D.	135 S. 98 D.	135 S. 97 D.	2′ 15″	1′ 30″	Slight	None	Cocain Quinin & Urea		34
35	E.E.	33	Septum	124 S. 90 D.	128 S. 96 D.	124 S. 90 D	2′ 30″	1′ 50″	None	None	Cocain		35
36	M. M.	43	Tonsils	140 S. 100 D.	148 S. 100D.	not taken	3′ 50″	2′	Arterial: controlled by pressure	None	Cocain Apothesine		36
37	H. L.	14	Tonsils	115 S. 80 D.	123 S. 85 D.	118 S. 82 D.	4′	2′ 30″	Slight	None	Ether		37
38	A. P.	20	Tonsils	125 S. 92 D.	138 S. 98 D.	138 S. 93 D.	3′	1′ 25″	Moderate	None	Ether		38
39	S. G.	24	Tonsils	133 S. 94 D.	147 S. 99 D.	140 S. 90 D.	4′	1′ 35″	Slight	None	Cocain Quinin & Urea		39
40	G. B.	9	Tonsils	100 S.	116 S.	99 S.	4′ 30″	2′ 30″	Slight	None	Ether		40

The Prophylactic Use of Pituitrin in Nose and Throat Operations under General and Local Anesthesia—*Cont.*

				BLOOD PRESSURE.			COAGULATION TIME.						
No	Name	Age	Operation	Before Injection	15 Min. After Injection	18 Hours Later	Before Injection	15 Min. After Injection	Primary Bleeding	Secondary Bleeding	Anesthesia Remarks	Remarks	No.
41	M. S.	19	Tonsils	126 S. 94 D.	140S. 94 D.	130 S. 86 D	2′	1′ 40″	Slight	None	Cocain Quinin & Urea		41
42	F B.	23	Tonsils	122 S. 90 D.	135 S. 95 D.	124 S. 92 D.	3′	1′ 50″	Slight	None	Ether		42
43	G. B.	18	Tonsils	119 S. 87 D.	130 S. 98 D.	127 S. 90 D.	4′	3′	Moderate	Slight about 8 hours later	Cocain Apothesine		43
44	J. D	26	Tonsils	120 S.	130 S.	123 S.	6′	2′ 30″	Moderate	None	Cocain Quinin & Urea	Small clot a few hours later	44
45	R. G.	21	Tonsils	120 S. 90 D.	135 S. 98 D.	128 S. 92 D.	4′	1′ 30″	Slight	None	Cocain Apothesine		45
46	L. B.	32	Tonsils	132 S. 94 D.	145 S. 99 D.	140 S. 95 D.	3′	1′ 25″	Slight	None	Cocain Quinin & Ur.	Had ½ strength HMC before op.	46
47	M. A	23	Tonsils	122 S. 90 D.	140 S. 98 D.	130 S. 92 D.	2′	1′ 20″	Arterial: controlled by pressure	None	Ether		47
48	M. P.	20	Tonsils	116 S. 80 D.	125 S. 84 D.	123 S. 86 D.	Not taken		Moderate	None	Ether		48

and that the coagulation time had been reduced in nearly every instance.

A short time ago I[7] took occasion to report the results in a series of 100 cases of my own in which pituitrin had been given as a prophylactic and for the control of postoperative hemorrhage. The results considered solely from the clinical point of view were very gratifying. Briefly they showed that in 35 tonsillectomies done under local anesthesia there was only one severe primary hemorrhage, four moderate and 29 slight. Five cases had a postoperative bleeding. In the 53 cases done under general anesthesia there was one severe primary hemorrhage, 16 moderate and 33 slight. There were no secondary or postoperative hemorrhages in this group.

My present report, read before the Sixth Annual Meeting of the American Association of Anesthetists, Chicago, Ill., June 9-10, 1918,[11] concerns 48 cases in which pituitrin was given solely as a prophylactic against hemorrhage and comprises a study not only of the amount of the bleeding but also of the effect on the blood pressure and coagulation time. The procedure was as follows: Blood pressure and coagulation time were taken and followed immediately by a hypodermic of pituitrin, 1 cc. to adults and ½ to 1 cc. to children. After a lapse of fifteen minutes the blood pressure and coagulation time were again taken and the patient sent to the operating room. As the majority of the cases were operated on in the afternoon, I had the blood pressure taken again on the following morning before the cases were dismissed from the hospital.

The striking features of these experiments, showing the action of the pituitrin were the uniform and prompt rise in blood pressure, the consistent lowering of the coagulation time and the absence of postoperative hemorrhage. These we shall consider seriatim.

BLOOD PRESSURE.

ALL OF THE CASES, with but one exception, showed a rise in blood pressure averaging 10 mm. systolic and 6 mm. diastolic, which was manifest fifteen minutes after the injection. This increase was maintained in 60 per cent. of the cases for as long as 18 hours. At the end of that time 18 per cent. of the remainder had reached the same level as prior to the injection and 22 per cent. had fallen below that level. This demonstrates that the action of pituitrin is far from being short-lived and corroborates the statement of Klotz, who asserted that the increase in blood pressure may be sustained for as long as 24 hours. *More significant in relation to the anesthesia is the fact that postoperative depression was combated to a great extent through the sustained blood pressure.* Pituitrin has been used in a number of surgical conditions for the treatment of shock. Being prolonged

11. SALINGER, SAMUEL: The Prophylactic Use of Pituitrin. American Jour. Surg., Anesthesia Supplement, October, 1918, Vol. xxxii, No. 10, 124-127.

in action, it exerts a twofold influence in these nose and throat operations when employed as a prophylactic and makes for a more prompt recovery.

COAGULATION TIME.

DETERMINING THE COAGULATION time of the blood is a more or less variable procedure because of the variety of methods that may be employed and the difference in judgment as to the exact moment when the coagulation may be considered complete. To be absolutely correct and avoid mixing the blood with tissue juices as in skin punctures one would have to take the blood directly from a vein. In the present series this was not feasible and we had to resort to the old-fashioned ear puncture, inaccurate though it may be for the determination of the absolute coagulation point. However, the method by which coagulation time is determined is really immaterial for comparative purposes as long as the same method is employed in each case on both occasions, the punctures made in the same manner, a free flow of blood established without massaging the tissues and drops of equal size examined. These precautions were observed and the results showed definitely a decrease in coagulation time of from ½ to 5 minutes. The slowest coagulating blood (case No. 9) which took nine minutes was reduced to four minutes by the pituitrin. There was only one case in which the coagulation was unaffected (case No. 18), although this case showed an average rise in blood pressure with a return to normal within 18 hours.

PRIMARY HEMORRHAGE.

THE AMOUNT OF BLOOD lost at the time of operation was none or slight in 74 per cent. and moderate in 26 per cent. of all cases. In relation to the anesthesia, of 15 cases done under ether, 10 were accompanied by slight and 5 by moderate bleeding of which 1 was controlled by ligature and the other 4 by pressure. Of 33 cases done under local anesthesia 25 showed a slight and 8 a moderate bleeding all of which were controlled by direct pressure.

POSTOPERATIVE HEMORRHAGE.

THERE WAS ONLY ONE case in which postoperative bleeding was noted, occurring eight hours after a moderate primary bleeding in a young woman of eighteen whose tonsils were removed under local anesthesia. This patient, by the way, showed a rise in blood pressure under the influence of pituitrin from 119 S.-87 D. to 130 S.-98 D., lasting until the following morning when the readings were 127 S.-90 D. Her coagulation time had been reduced from four to three minutes. Aside from this case there was only one other patient who had a clot form in the tonsillar fossa, the remainder being entirely free from blood.

Considering the series as a whole 13 of the 48 cases showed a moderate primary hemorrhage and 35 only a slight bleeding. I employ the latter term as referring to a bleeding that ceases promptly after the wound had been made and requires no topical application of any sort. Of the 13 moderate hemorrhages, 8 were venous easily controlled by direct sponge pressure. The other 5 were distinctly arterial, the spurters being either clamped or compressed. (In one case a ligature was applied.)

The fact that there was only one postoperative hemorrhage, that being a very slight one, is evidence of the efficacy of the prophylactic which is further borne out by the persistence of the action of the pituitrin as shown by the continued elevation of blood pressure.

As to untoward manifestations directly attributable to the pituitrin, the only one noted was the occurrence of uterine contractions in several of the female patients. Some of them complained of *cramps* a short time after the administration of the hypodermic which lasted from fifteen minutes to an hour but were not severe enough to require any particular attention.

In closing it must be pointed out that pituitrin is contraindicated in cases of arteriosclerosis or high blood pressure from other causes.

I desire to express my appreciations to Dr. L. B. Phelps of the staff and Drs. Casserly and Adamo, internes of the Francis Willard Hospital.

TRENDELENBURG ANESTHESIA AND OTHER FACTORS OF SAFETY IN ABDOMINAL HYSTERECTOMY . PREPARATION OF THE PATIENT . SKILLED ANESTHETISTS . TRENDELENBURG ANESTHESIA . THE SURGICAL TECHNIC . ROUTINE POSTOPERATIVE CARE, MEDICATION, DIET AND CLINICAL RESULTS .

DONALD GUTHRIE, M. D. ROBERT PACKER HOSPITAL SAYRE, PENNSYLVANIA.

HYSTERECTOMY IS STILL ATTENDED by an unwarranted mortality. Hence it is a pleasure to have Donald Guthrie, of Sayre, Pa., revive interest in the factors of safety in this operative procedure. Carrying his message, first to the Pennsylvania State Medical Association, in 1917, and later to the Joint Meeting of the Interstate Association of Anesthetists and the Indiana State Medical Association, in Indianapolis, September 25-27, 1918, Guthrie shows how with skilled anesthetists, Trendelenburg anesthesia, proper surgical technic and care, the mortality of hysterectomy may be reduced to less than 1.5 per cent.

The modern methods of preparing patients for operation, the improvement in the operative technic and anesthesia, and intelligent postoperative care, have made the operation of abdominal hysterectomy a safe procedure. In reviewing our 551 hysterectomies of all types performed in the last seven and one-half years, we are impressed with the following factors of safety:

PREPARATION OF THE PATIENT.

FIRST: THE PREPARATION of the patient. It is important for the surgeon to know the exact physical condition of every patient presenting herself for operation. This necessitates careful history taking, careful examination of the chest, the circulation, the condition of the blood stream, the nervous system, and kidney efficiency. Patients who have suffered severe loss of blood at the menstrual time we believe should be operated upon just before the onset of the next period, giving the body a chance to recover from the last severe hemorrhage. Women with severe metrorrhagia, flowing at the time of examination, should be given salines, and tonics, and such measures should be carried out that will tend to stop the hemorrhage and give the body a chance to recuperate. If the hemoglobin is reduced below 40 per cent. and the bleeding cannot be controlled, direct transfusion of blood from some blood relation is a valuable aid in the preparation as was borne out in five of our cases. I am satisfied these patients could not have stood operation had not transfusion been performed.

Two factors which promote postoperative shock are *loss of sleep* and *dehydration*. In our preparation of patients for any adbominal operation we consider these two factors carefully. In nervous excitable cases with insomnia we advise a few days' rest in the hospital, and are careful to see that these patients sleep well at night.

We do not employ preoperative purgation in any form, believing that it is not only a useless measure, but a harmful one. Large amounts of fluid are lost by the purge and a night which should be spent in comfort and rest is made a veritable nightmare. Alvarez and Taylor have shown experimentally that the purged gut is less able to empty itself and is more distented than one that has not been purged. All surgeons have noticed how much easier it is to operate upon the emergency case with the collapsed bowel than upon those who have been thoroughly prepared with their empty but distended coils, and yet, we all have been slow to realize that purgation is not only unnecessary but harmful.

We rely upon a morning enema to empty the lower bowel, except in the patient who is obstinately constipated. She is given a small dose of cascara the night before operation and the morning enema. If the operation does not come until late in the morning we allow our patients hot coffee, or broth when they are awakened.

We plan to have the patients lose as little fluid as possible on the operating table; therefore, our operating rooms are at normal room temperature instead of excessively hot. The patients are not wrapped in blankets, and no measures are taken to keep the operating table warm. It is seldom necessary to change the patient's night garment on the table after the operation is over because of perspiration.

In all cases of hysterectomy the patients are shaved in the afternoon and the abdomen treated with tincture of iodin. This is repeated just before operation. In addition the vagina is washed out well with soap and water, and a 1 to 5,000 bichlorid douche given. This is repeated on the table should the case be one for complete hysterectomy.

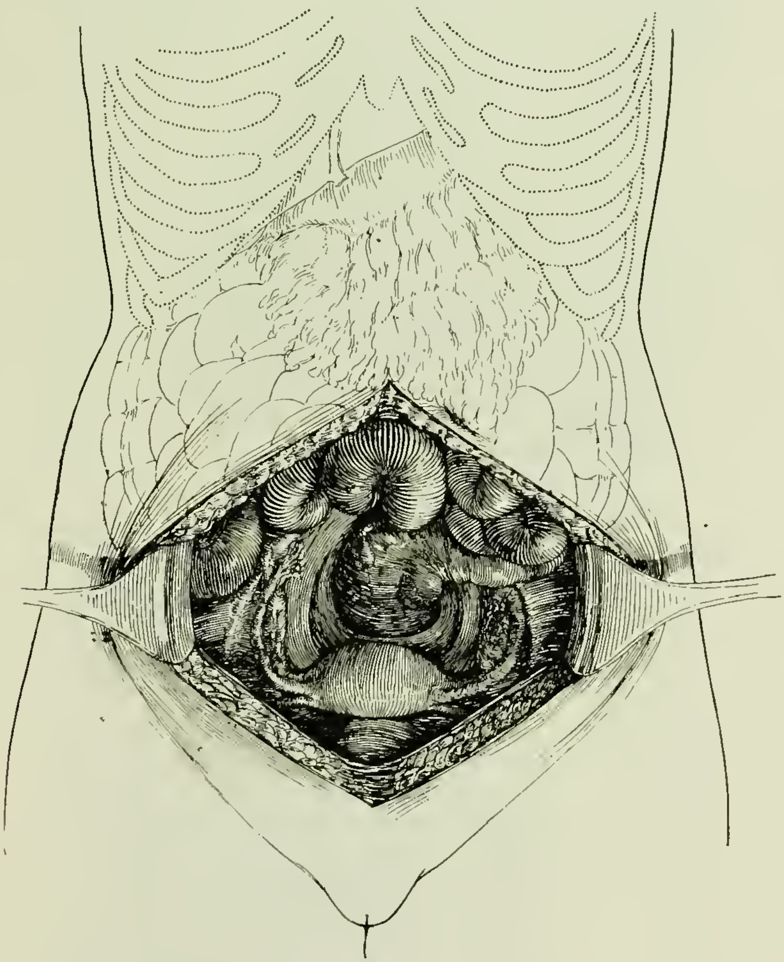

Fig. 1.—Trendelenburg Anesthesia. Showing the coils of small intestine gravitated out of the pelvis when the patient is anesthetized in the Trendelenburg position.

Fig. 2.—Lifting up abdominal wall to free pelvis of any coil of small intestine.

SKILLED ANESTHETIST AND TRENDELENBURG ANESTHESIA.

THE VALUE OF GOOD anesthesia by a trained anesthetist cannot be too strongly advised. The responsibility of the anesthetist in major operations is next to that of the surgeon. Most hospitals today have the services of skilled anesthetists. The personality of the anesthetist is most important, for he or she can by skilled suggestion calm the most nervous patient. In all of our cases of pelvic surgery we employ the Trendelenburg anesthesia. The anesthetic is started with the patient in the Trendelenburg position on the operating table. It is not necessary to have all patients come to the operating room, but if the anesthetic is given in an anesthetizing room the patient is put to sleep in the Trendelenburg position on the table which is to be used during the operation. Here, the personality of the anesthetist is most important, for by suggestion the fears of the patient caused by the slight discomfort in beginning the anesthetic in this position, can be allayed.

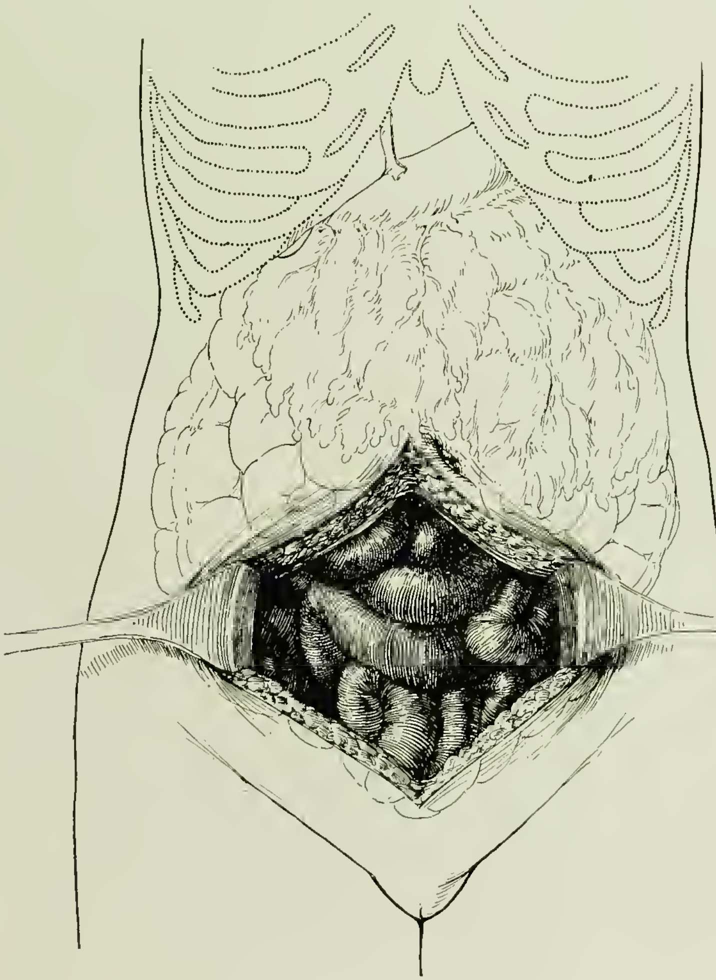

Fig. 3.—Compare the difference in the amount of small intestine in the pelvis when the patient is anesthetized in the dorsal position.

We all know that trauma to the small intestine is a great factor in the production of shock. In this type of anesthesia it is planned to have the small intestine out of the pelvis when the abdomen is opened. If Trendelenburg anesthesia is used it is usual to find but a coil or two of small intestine in the pelvis, and it is seldom ever necessary to use more than one small square of gauze to get excellent exposure (Fig. 1). When we open the peritoneum we insert two fingers into the abdomen and lift the abdominal walls well up (Fig. 2). The inrushing air will cause any ference in the amount of gauze used to obtain exposure (Fig. 3). Trauma to the small intestine varies with the amount of packing necessary. We consider this method one of the safe factors in preventing shock in pelvic operations. Should the pelvis not be infected the gallbladder is explored by touch before packing is inserted. If

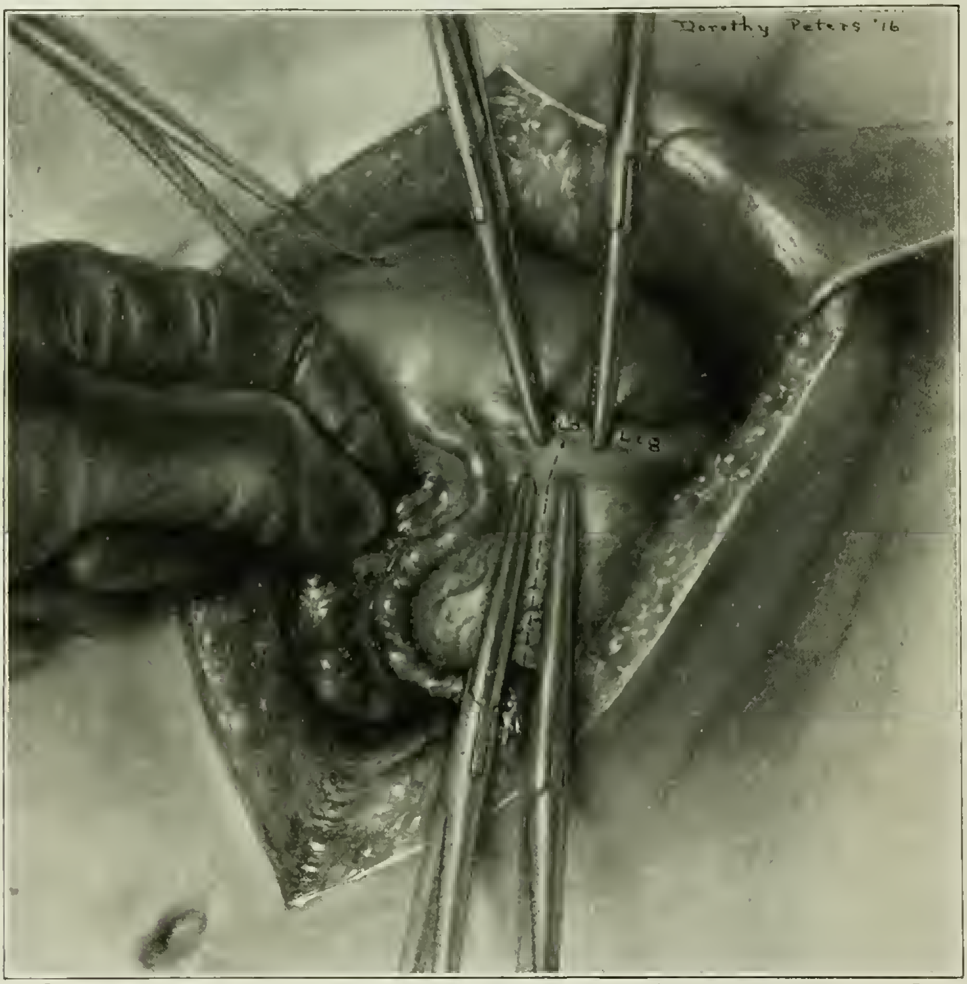

Fig. 4.—Forceps applied to broad ligaments, including ovarian arteries, and forceps placed on round ligaments.

coil of intestine that has not gravitated out of the pelvis to slide upward. When this method is compared with the one usually employed, of putting the patient to sleep in the dorsal position, making the incision, then calling for the Trendelenburg position, it is amazing to see the dif- gallstones are found the question as to whether or not they should be attended to depends upon the condition of the patient at the end of the pelvic operation. The appendix is always removed after hysterectomy unless some critical state of the patient contraindicates its removal.

THE SURGICAL TECHNIC

IN OUR OPERATION for abdominal hysterectomy we use the clamp method, clamping and cutting first the broad ligaments containing the ovarian arteries on both sides, next the round ligaments separately (Fig. 4). After freeing the uterus on both sides in this manner we dissect the fold of the peritoneum on the anterior surface of the uterus, push the bladder forward, then isolate the uterine vessels on both sides and cut between the clamps (Fig. 5). The cervical canal is wiped off with gauze wet in bichlorid. We do not use any strong antiseptic here, fearing that if a slough is produced it may favor intestinal adhesions. In two of our earlier cases the patients had to be operated on for this condition. The objection some few men have to the clamp operation is the fear that it produces thrombosis in the veins. This I do not believe because the results in vaginal hysterectomies where clamps were used are good, and pulmonary embolism is not any more common in this class of work than

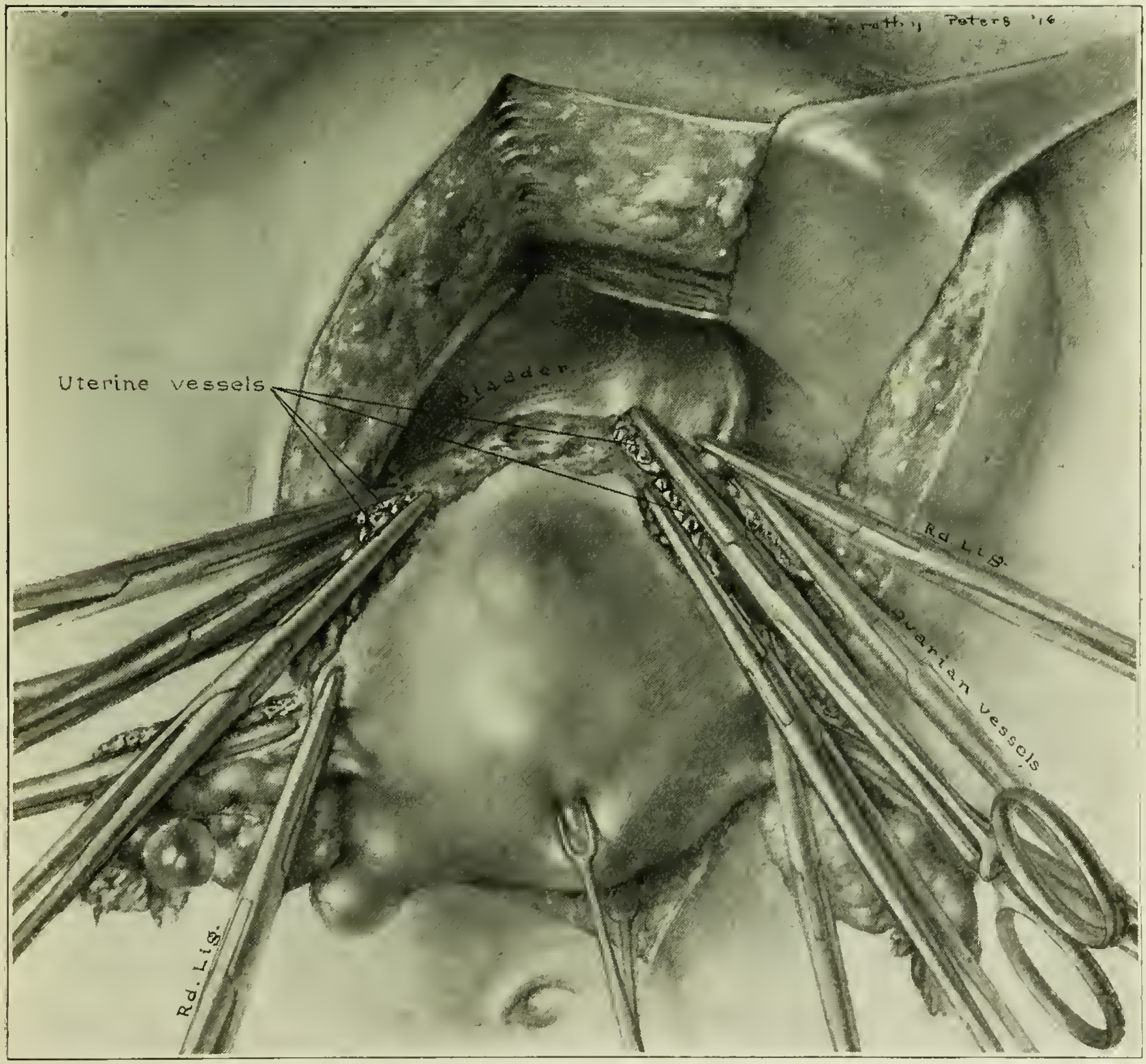

Fig. 5.—Showing uterus freed on all sides. Clamps on uterine vessels. Bladder pushed forward.

in any other. Our sutures are placed well behind the clamps and are placed in immediately so that if thrombosis has occurred it would be in the vessel at the distal side of the ligature. We do not use mass ligatures of any kind nor do we use the old pedicle needle. The vessels in the broad ligaments are secured by using a safety tie, then a lock suture throughout. The uterine vessels are ligated after fixing the ligature along the side of the cervix by a safety tie and then securing the vessels firmly by another tie of the same ligature (Fig. 6).

If a panhysterectomy is to be performed we isolate the ureters by splitting the posterior peritoneum, following them throughout their course. In a few cases we have used the ureteral catheter passed in the ureter and left in place. This makes it easy to recognize these structures, as they pass close to the cervix. To my knowledge we have never cut or ligated a ureter in a panhysterectomy. In cutting across the body of the cervix we use a conical incision which favors coaptation of the cervical margins. It is most important, I believe, to close up the cervix care-

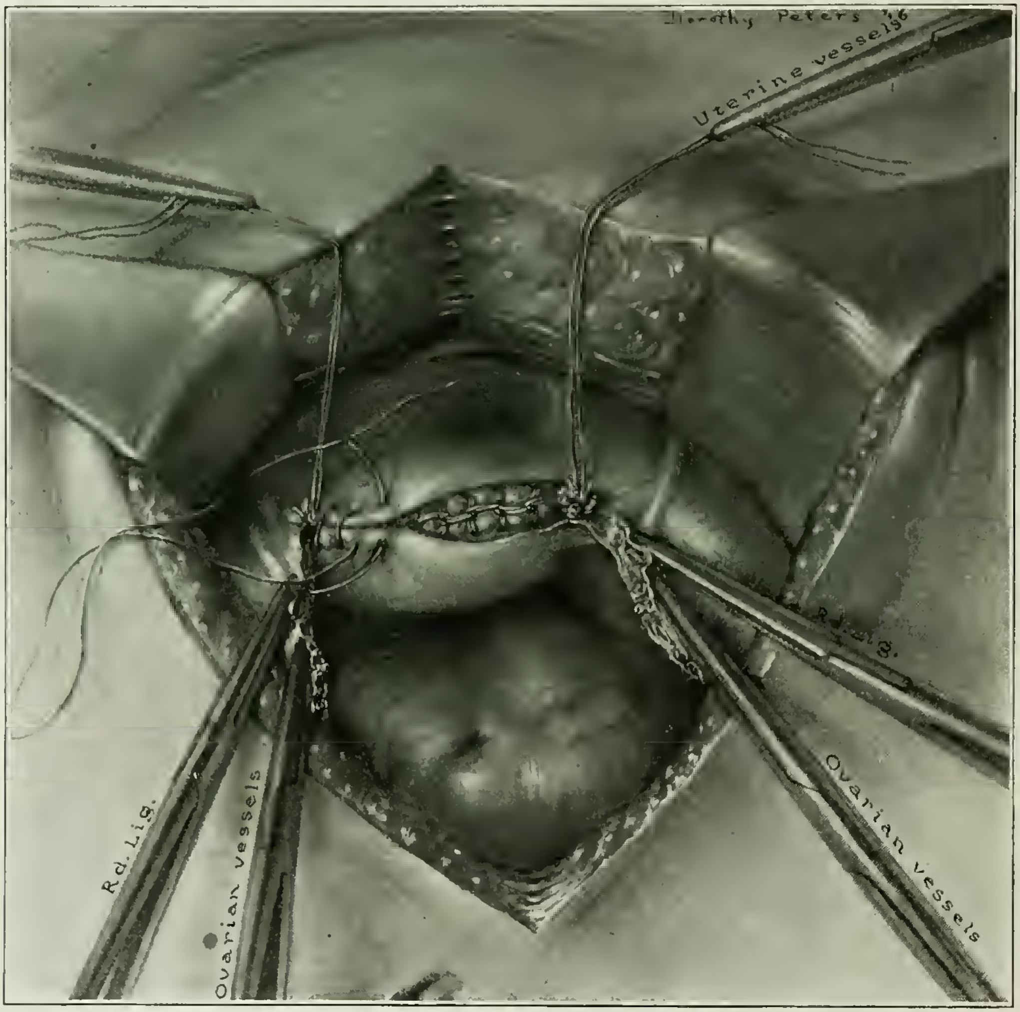

Fig. 6.—Method of securing vessels in broad ligament. Stump of cervix closed and peritoneal folds carefully coaptated.

fully, and to bring back the anterior peritoneal fold sutured to the posterior peritoneum (Fig. 6). In multiparous women with relaxed vaginal outlets we suture the round ligaments across the cervical body to prevent prolapse of the cervix into the vagina. An equal pull from each side tends to hold the cervix well up in the vagina interrupted sutures of chromic catgut in the muscle and fascia. This is a safer method than a continuous stitch. These sutures are not tied tightly.

POSTOPERATIVE CARE.

I CANNOT ADVISE TOO strongly that the operating surgeon see his patients daily, and

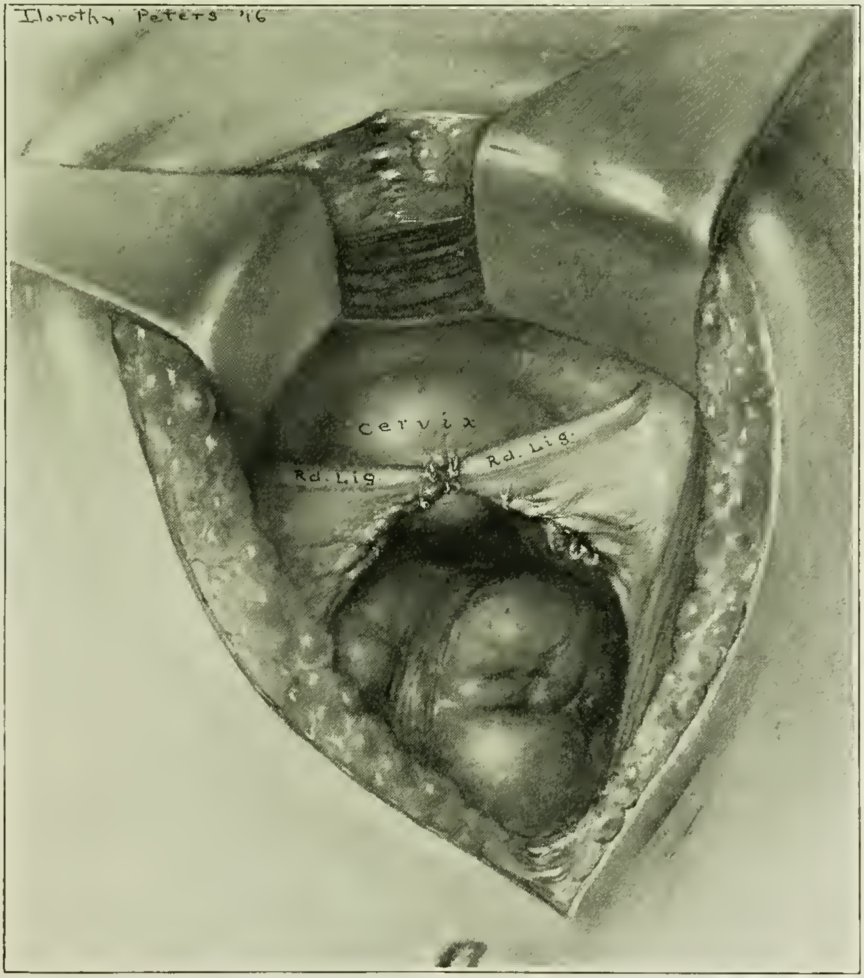

Fig. 7.—Showing the round ligaments sutured to cervical stump to prevent prolapse of cervix and vagina.

(Fig. 7). Before closing the abdomen we bring the omentum down into the pelvis, completely covering the operative field, and all coils of the small intestine, which have gravitated back in the pelvis. By so doing, the liability for adhesions is lessened. In the closure of our wounds we use a continuous stitch in the peritoneum and at frequent intervals after operation. The responsibility of the postoperative care of patients should not be entrusted entirely to the house doctors and nurses. Oftentimes complications may be early recognized by the surgeon and combated, which would be overlooked by subordinates if they had complete care of the patient.

We plan to have our patients made just as comfortable as possible during their postoperative course. They are kept in quiet recovery rooms for the first two or three days in the constant charge of a nurse. As soon as they are awakened they are given by mouth an ounce of olive oil. If they vomit it they get rid of a lot of ether, and it is usually the only time they do vomit. Fluids by mouth are given early and in large amounts if they are retained. We have discontinued the Murphy drip except for those who are dehydrated and shocked, believing that it causes reverse peristalsis and increases gas pain. Instead we use a large rectal tube left in place for forty-eight hours. Food is given early because it is the best stimulant for peristalsis that we have. Most of our cases of hysterectomy have soft diet on the second day after operation and have a natural bowel movement on the third day.

We give 1-6 grain of morphin and 1-150 grain of atropin twenty minutes before anesthesia. Morphin is given frequently but in small amounts for the first forty-eight hours after operation. Our practice is to give 1-12 grain hypodermically every four hours. When the abdomen has not been drained we use a five-pound sand bag for the first three days believing that its weight helps to restore normal intraabdominal pressure and prevents distention. One condition that we watch closely is the postoperative atony of the stomach, which in some cases if not recognized is a precursor of acute dilatation of the stomach, or acute gastromesenteric ileus. Any patient who has regurgitation or vomiting on the second day, or one who is restless, worried, or somewhat distended, has a lavage performed. If there is any tendency at all to acute dilatation, the stomach is washed out every three hours with good hot water. We employ all other means possible for retention of the urine other than the catheter. We fear its use and only restort to it when all other methods fail.

RESULTS.

WE HAVE HAD NO postoperative hemorrhages in any of our cases, and I did not see a postoperative hemorrhage in the many hundred cases of hysterectomy that I took care of at Rochester. The lock suture in the broad ligament is certainly a safer method than that of mass ligatures.

Two of our patients developed acute obstruction of the bowels due to a loop of the small intestine becoming adherent to the cervical stump. This occurred when we were using the carbolic acid and alcohol treatment of the cervical stump. It is my belief that sloughing occurred which caused these adhesions. Both of these patients were operated upon early during the obstruction; one recovered and one died. Our plan now is to mop off the cervical stump with a weak bichlorid solution.

In the past seven and one-half years we have performed 551 operations of hysterectomy. Out of this number 374 were supravaginal hysterectomies, 63 were complete or panhysterectomies, and 114 were vaginal hysterectomies. We have had 8 deaths or a mortality of 1.4 per cent.

In the series of 374 supravaginal hysterectomies there were three deaths,—two from acute intestinal obstruction and one from acute dilatation of the stomach.

Among the 114 vaginal hysterectomies there were three deaths,—one from general peritonitis, one from pulmonary embolism two weeks after operation, and one from postoperative ileus.

Of the 63 panhysterectomies there were two deaths,—one from pneumonia and one from peritonitis.

Excluding the one unavoidable death from pulmonary embolism the operative mortality for the series is 1.2 per cent.

THE STABILITY OF THE ACID-BASE EQUILIBRIUM OF THE BLOOD IN NATURALLY NEPHROPATHIC ANIMALS AND THE EFFECT ON RENAL FUNCTION OF CHANGES IN THIS EQUILIBRIUM . A STUDY OF NATURALLY NEPHROPATHIC ANIMALS AND OF THE FUNCTIONAL CAPACITY OF THEIR KIDNEYS FOLLOWING AN ANESTHETIC . THE EFFICIENCY OF AN ALKALI IN PROTECTING AGAINST THE TOXIC EFFECT OF AN ANESTHETIC . THE DECREASED PLASMA BICARBONATE DURING ANESTHESIA AND ITS CAUSE . A REPORT OF PLASMA BICARBONATE, BLOOD AND URINE KETONE AND BLOOD CATALASE ANALYSES IN OPERATIVE PATIENTS . TECHNIC . SUMMARY AND CONCLUSIONS . LOW LEVELS OF CARBON DIOXID AND ALKALI INDUCED BY ETHER . THEIR PREVENTION AND REVERSAL . RELATION TO ANESTHESIA AND OPERATION .

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AIDED BY A GRANT from the Rockefeller Institute for Medical Research and pursuing his investigations in the laboratory of the University of North Carolina, Wm. deB. MacNider, of Chapel Hill, has contributed to the Journal of Experimental Medicine, October 1, 1918, some interesting studies in the renal function of naturally nephropathic animals under anesthesia and in the protective efficiency of an alkali against the toxic effects of an anesthetic.

As a result of the observations of Ophüls,[1] Pearce,[2] and Dayton,[3] the fact is generally known that many of the lower animals, particularly the dog, are susceptible to a type of kidney injury which should be classed as a chronic nephropathy. In a recent study[4] of the naturally acquired chronic nephropathy of the dog these earlier observations have been confirmed, the various nephropathic processes have been classified, and a consideration of the processes of repair in the kidneys has been undertaken. In this study of forty-two naturally nephropathic animals I found it possible, with three exceptions, to classify the kidney injury as a chronic productive type. The three remaining animals showed the typical arteriosclerotic type of kidney with extensive general sclerosis of the vessels. The thoracic aorta in one of the animals was the seat of a fusiform aneurysm. In the majority of kidneys of the remaining thirty-nine animals the formation of connective tissue was a focal process confined to the glomeruli. In all the animals both the capsule and capillaries of the glomeruli participated in the laying down of connective tissue so that in the different animals it was not possible to specialize the glomerular pathology into a capsular and intracapillary glomerulonephropathy. Hyaline degeneration of the fibrosed capillary tufts was ocassionally observed.

The formation of intertubular connective tissue in the kidneys of these animals has shown no parallel with the degree of fibrosis which has taken place in the glomeruli, and, furthermore, there has existed a notable disproportion between the severity of the changes in the glomeruli and the degree of degeneration of the tubular epithelium. This observation has been recently confirmed by Stengel, Austin, and Jonas[5] in a study of the chronic nephropathies in human material.

The above outline of the naturally acquired chronic nephropathy of the dog not only estab-

1. Ophüls, W.: Some Interesting Points in Regard to Experimental Chronic Nephritis. J. Med. Research, 1908, Vol. xviii, 497.
2. Pearce, R. M.: An Experimental Study of Nephrotoxins. Univ. Penn. Med. Bull., 1903-04, Vol. xvi, 217.
3. Dayton, H.: Reliability of Dogs as Subjects for Experimental Nephritis. J. Med. Research, 1914-15, Vol. xxxi, 177.
4. MacNider, W. deB.: A Pathological and Physiological Study of the Naturally Acquired Chronic Nephropathy of the Dog. Part I, J. Med. Research, 1916, Vol. xxxiv, 177.
5. Stengel, A., Austin, J. H., and Jonas, L.: A Comparison of the Functional and Anatomic Findings in a Series of Cases of Renal Disease. Arch. Int. Med., 1918, Vol. xxi, 313.

lishes the frequency of the occurrence of such conditions in these animals but shows the close histological resemblance between certain nephropathies of the lower animals and man.

The ability to obtain such material for experimental purposes offers many possibilities for the study of the chronic nephropathies and for the study of various acute processes which may be superimposed upon the naturally acquired chronic kidney injury.

The first study[6] of this character has consisted in an investigation of the functional response of the naturally nephropathic kidney after the kidney had been acutely injured by uranium nitrate or by an anesthetic. An analysis of these experiments shows that when a naturally nephropathic animal is anesthetized by Gréhant's anesthetic, or when the animal is given uranium and anesthetized by ether, the animals fall into two clearly defined groups. One group of animals during the anesthesia becomes rapidly anuric and fails to show a functional response to such diuretic substances as theobromin, caffein, and solutions of urea and glucose. The second group of animals remains diuretic following the anesthetic and shows a functional response to the diuretic substances which in the first group of animals were of no diuretic value.

A physiological study of the response of the vascular mechanism of the kidney in the anuric and diuretic groups of animals by the use of such peripherally acting stimuli as the members of the caffein group and adrenalin has shown this mechanism to be responsive in both groups of animals. The degree of vasodilation or constriction of the renal vessels induced by caffein or adrenalin was usually greater in the anuric than in the diuretic groups of animals. Renal vasodilation effected by caffein, theobromin, or solutions of urea or glucose in the diuretic group of animals was associated with a free diuresis, while with the production of an even greater degree of vasodilation by these substances in the anuric animals no formation of urine was induced.

The histological study of the kidneys of these two groups of animals has shown a chronic productive nephropathy in which the changes were largely confined to the glomeruli. As a result of the use of uranium or an anesthetic no acute degenerative changes had developed in the glomeruli. The vascular pathology in the two groups has shown no elements of difference. The acutely developing pathological change which differentiates the anuric from the diuretic groups of animals has consisted in the degree of degeneration occurring in the tubular epithelium, and especially in the epithelium of the convoluted tubules. The animals which have remained diuretic and responsive to diuretic substances have shown but slight epithelial damage, while the group of animals that have been rendered anuric by the anesthetic and non-responsive to the same diuretic substances have shown a swelling and necrosis of the convoluted tubule epithelium. The ascending limbs of Henle's loops have contained a large amount of stainable fat.

The following investigation has been undertaken with the object in view of ascertaining the difference in the response of the normal and naturally nephropathic kidney to Gréhant's anesthetic, the principal anesthetic ingredient of which is chloroform. The study embraces an investigation of the acid-base equilibrium of the blood in these two groups of animals, prior to and during the period of anesthesia, and the association of the changes in this equilibrium with the development of an anuria. The functional capacity of the kidney has been determined by the phenolsulphonephthalein test, the retention of blood urea, and the response of the kidney during the period of anesthesia to various diuretic substances. Finally, the relative toxicity of this anesthetic for the normal as compared with the naturally nephropathic kidney has been investigated by a histological study of the kidneys at the termination of the experiments.

EXPERIMENTAL.

DOGS WERE EMPLOYED in the experiments which furnish the basis for this study. Nine of the animals were healthy dogs varying in age from 8 months to 6 years and 2 months. Eighteen of the dogs were naturally nephropathic and varied in age from 3 years to 13 years and 1 month. Both the normal animals which served as controls and the naturally nephropathic animals were placed in metabolism cages, given 500 cc. of water daily, and fed on bread with a small amount of cooked meat. The animals were studied for 3 days prior to the day of experiment. During this period the urine was collected twice a day and examined qualitatively for albumin, glucose, acetone, and diacetic acid. Quantitative determinations of these substances were made when present. The centrifugalized urine was examined for casts. The hydrogen ion content of the blood was determined by the method of Levy, Rowntree, and Marriott,[7] the

6. MacNider: A Pathological Study of the Naturally Nephropathic Kidney of the Dog, Rendered Acutely Nephropathic by Uranium or by an Anesthetic. Part II, J. Med. Research. 1916, Vol. xxxiv, 199.

7. Levy, R. L., Rowntree, L. G., and Marriott, W. McK.: A Simple Method for Determining Variations in the Hydrogen Ion Concentration of the Blood. Arch. Int. Med., 1915, Vol. xvi, 389.

alkali reserve of the blood and the tension of carbon dioxid in alveolar air by the methods of Marriott, [8, 9] while the blood urea was determined by the method of Marshall[10] as modified by Van Slyke and Cullen.[11] The phenolsulphonephthalein test for kidney function was conducted according to the technic of Rowntree and Geraghty.[12]

At the end of the 3 day period allowed for normal observations the animals were given 300 cc. of water and 3 hours later were given 60 cc. per kilo of Gréhant's anesthetic by stomach tube. Half an hour was allowed for the development of a degree of anesthesia sufficient for the surgical part of the experiment. The first observations were made on the anesthetized animals 1 hour after they had received the anesthetic and half an hour after the development of a satisfactory state of general anesthesia. At half hour periods during the course of the experiments the flow of urine per minute was recorded and the hydrogen ion content and reserve alkali of the blood were determined. At these intervals the animals were given intravenously one of the following diuretic substances: caffein citrate or theobromin sodium salicylate in 1 per cent. solution, 1 cc. per kilo; pituitrin (Parke, Davis and Company) 0.5 cc.; or solutions of urea or glucose. The urea solution was of 0.9 per cent. strength in 0.9 per cent. sodium chlorid and was given in the quantity of 10 cc. per kilo. The glúcose solution was 20 per cent. strength in 0.9 per cent. sodium chlorid and was given in the same quantity per kilo as was the urea solution.

The experiments on the anesthetized animals were terminated at the end of 1½ hours at which time the tension of carbon dioxid in alveolar air was determined and the kidneys were removed for the histological study.

OBSERVATIONS ON NORMAL AND NATURALLY NEPHROPATHIC ANIMALS PRIOR TO AN ANESTHETIC.

THE FOLLOWING OBSERVATIONS which have extended over a period of 3 days have been recorded in Table I. In this table observations on two normal or control animals have been tabulated with similar observations on nine of the naturally nephropathic animals.

In recent papers [13, 14] studies have been made of the relative stability of the acid-base equilibrium of the blood in animals of different ages. In these studies it was found that the older animals were more susceptible to agents which altered this equilibrium in favor of the acid ion than were the younger animals. For this reason relatively young animals were selected for the controls in these experiments. The factor of the age of the animals as expressed by the ease with which the nephropathic animals develop an acid intoxication cannot be accurately determined in these experiments, since the existence of the chronic nephropathy in the animals, as will be demonstrated later in this study, makes them more susceptible to changes in the acid-base equilibrium. The naturally nephropathic animals have, however, been arranged in the table according to their age. The influence of this factor in determining the toxicity of the anesthetic will be referred to in a later part of this paper.

Reference to Table I shows the control animals to be freely diuretic and the urine to be free from albumin, glucose, acetone bodies, and casts. The hydrogen ion content of the blood has varied from 7.3 to 7.45, while the reserve alkali has shown a variation from 8 to 8.1 The hydrogen ion determinations by the method employed in

8. Marriott, W. McK.: A Method for the Determination of the Alkali Reserve of the Blood Plasma. Arch. Int. Med., 1916, Vol. xvii, 840.

9. Marriott: The Determination of Alveolar Carbon Dioxid Tension by a Simple Methcd. J. Med. Assn., 1916, Vol. lxvi, 1594.

10. Marshall, E. K., Jr.: A Rapid Clinical Method for the Estimation of Urea in Urine. J. Biol. Chem., 1913, Vol. xiv, 283.

11. Van Slyke, D. D., and Cullen, G. E.: A Permanent Preparation of Urease, and its Use in the Determination of Urea. J. Biol. Chem., 1914, Vol. xix, 211.

12. Rowntree, L. G., and Geraghty, J. T.: An Experimental and Clinical Study of the Functional Activity of the Kidneys by Means of Phenolsulphonephthalein. J. Pharmacol. and Exp. Therap., 1909-10, Vol. i, 579.

13. MacNider: A Consideration of the Relative Toxicity of Uranium Nitrate for Animals of Different Ages. Part I, J. Exp. Med., 1917, Vol. xxvi, 1.

14. MacNider: Concerning the Influence of the Age of an Organism in Maintaining its Acid-Base Equilibrium. Science, 1917, Vol. xlvi, 643.

these experiments do not show a correlation with the reserve alkali determinations or the determinations of alveolar air carbon dioxid. The Levy-Rowntree-Marriott method is an expression of both the volatile and non-volatile acid content of the blood. Even a local accumulation of carbon dioxid in the blood of a part, such as the arm or leg, may give a very high reading and is not a true expression of the non-volatile acid content of the blood. For this reason the alkali reserve determinations and the variations in alveolar air carbon dioxid tension more accurately indicate the changes in the hydrogen ion content.

The determinations of alveolar air carbon dioxid for the normal animals have varied between 37 and 40 mm. and have shown a correlation with the maximum and minimum variations of the reserve alkali of the blood.

The blood urea estimations have remained very constant. In one of the nine control animals the percentage of urea was 0.014 per cent., while in the remaining animals the blood urea was 0.012 per cent. The phenolsulphonephthalein test was made on six of the control animals. The total output of the dye in a 2-hour period varied from a minimum of 73 per cent. to a maximum of 81 per cent.

A study of the observations on the naturally nephropathic animals prior to an anesthetic (Table I) shows a marked variation in the output of urine by the different animals in a 24-hour period. This has varied in the respective animals from 174 to 820 cc. The urine of all the animals contained albumin and casts. In all but two of the animals albumin was present as a mere trace. In one animal the urine contained 1.2 gm. of albumin per liter. This animal (Experiment 5, Table I) as contrasted with the other naturally nephropathic animals showed a depletion in the alkali reserve of the blood, a decrease in the tension of alveolar air carbon dioxid, and a marked reduction in the elimination of phenolsulphonephthalein. None of the naturally nephropathic animals of this series has shown the presence of acetone bodies in the urine. The hydrogen ion determinations have been variable as was the case with the control animals. With one exception (Experiment 5, Table I) the alkali reserve of the blood and the tension of alveolar air carbon dioxid in the naturally nephropathic animals have been within the range of normality. The reserve alkali in these animals has varied from 8 to 8.1, while the carbon dioxid tension has varied between 32 and 41 mm. This minimum variation of 32 mm. in carbon dioxid tension does not correlate with the reserve alkali reading

TABLE I.

Observations on Normal and Naturally Nephropathic Animals Prior to an Anesthetic.

Experiment Number	Age of Animals	Weight	Water in 24 hrs.	Urine in 24 hrs.	Albumin and casts	Acetone and diacetic acid	pH	R. pH	Carbon dioxid	Blood urea	Phenol-sulphonephthalein
	yrs.	kg.	cc.	cc.					mm.	per ct.	per ct.
1 (control)	1	8.2	500	481	0	0	7.3	8.0	37	0.012	
2 (control)	3	13.66	500	287	0	0	7.45	8.1	40	0.012	81
3	1-2	11.3	500	174	Tr. Casts.	0	7.45	8.15	40	0.015	68
4	1-2	21.53	500	518	Tr. Casts.	0	7.45	8.1	39		
5	1-2	7.32	500	389	1.2 gm. Numerous casts.	0	7.45	7.9	36	0.018	54
6	3 yrs. and 4 mos.	11.4	500	584	Tr. Casts.	0	7.4	8.0	40		
7	8	17.7	500	820	Tr. Casts.	0	7.45	8.1	40		
8	10	23.1	500	508	Tr. Casts.	0	7.45	8.0	38		
9	10-11	21.55	500	355	Tr. Numerous casts.	0	7.35	8.0	38	0.015	61
10	12	23.4	500	718	Tr. Few casts.	0	7.45	8.0	41	0.015	69
11	13 yrs. and 1 mo.	30.35	500	520	0.9 gm. Few casts.	0	7.45	8.1	32	0.028	52

for the blood which was 8.1. The question arises as to whether or not some local pathology in the lung of this very old animal could not have been responsible for this atypical reading.

The blood urea determinations have shown a retention in all the naturally nephropathic animals, varying from 0.015 to 0.028 per cent. The elimination of phenolsulphonephthalein has been reduced in all the animals and, as is shown in Table I, there is a relation between the retention of blood urea and the elimination of phenolsulphonephthalein The animal of Experiment 11, with the greatest retention of blood urea, 0.029 per cent., also shows the greatest reduction in the output of phenolsulphonephthalein which was 52 per cent. The animals with a lower percentage retention of blood urea have a higher percentage elimination of the dye.

From the foregoing analysis of observations on the control and naturally nephropathic animals prior to the use of an anesthetic, the following conclusions are permissible: (1) The control animals show no evidence of a kidney injury and have a normal acid-base equilibrium. (2) The naturally nephropathic animals give evidence of a chronic kidney injury by the formation of a variable amount of urine which contains albumin and casts, by a retention of blood urea, and by a decrease in the elimination of phenolsulphonephthalein. (3) The naturally nephropathic animals with one exception, Experiment 5, show a normal acid-base equilibrium. (4) In the naturally acquired chronic nephropathy of the dog in which the chronic pathology is largely confined to the glomeruli an acid intoxication is not the primary cause for the kidney injury. (5) In such chronic nephropathies blood urea determinations and estimations of the ability of the kidney to eliminate phenolsulphonephthalein are of more diagnostic value than determinations of the acid-base equilibrium of the blood.

OBSERVATIONS ON NORMAL AND NATURALLY NEPHROPATHIC ANIMALS AFTER AN ANESTHETIC.

AN ANALYSIS OF THE response of the control animals to Gréhant's anesthetic as indicated in Table II shows these animals to have remained diuretic following the development of a state of surgical anesthesia. The urine flow varied between 1 and 2 drops per minute for both animals. Half an hour after the establishment of a state of anesthesia the urine flow was unaffected and no change from the normal alkali reserve reading of 8 to 8.1 had occurred. During the remaining hour of the experiment these animals were freely diuretic to theobromin, caffein, pituitrin, and a solution of glucose. The flow of urine from pituitrin was increased from 5 to 20 drops per minute and an even greater diuretic effect was obtained from the glucose solution, the urine increasing from 5 to 26 drops per minute.

During the course of the experiments the control animals were able to maintain their normal acid-base equilibrium. The alkali reserve of the blood failed to show any depletion and the tension of carbon dioxid in alveolar air remained practically unaffected. At the end of the experiment the control animals were forming a larger amount of urine than was the case at the commencement of the anesthesia. At the commencement of the experiments the urine flow per minute for the animals of Experiments 1 and 2 was 2 and 1 drops for the respective animals, while at the termination of the experiments the urine flow was 3 and 6 drops per minute for these animals.

The histological study of the kidneys of the control animals has been negative in as far as demonstrating any pathological change induced by the anesthetic. The glomerular vessels are distended with blood and the capillary loops usually fill the capsular space. The tubular epithelium, and especially that of the convoluted tubules, is shrunken, the nucleus-plasma relationship has increased in favor of the nucleus, and the nuclei are hyperchromatic and stain intensely. The ascending limbs of Henle's loops either contain no stainable fat or a very small amount of fat in the form of dust-like particles.

A study of the response of the naturally nephropathic animals to Gréhant's anesthetic given in the same quantity per kilo as was the case with the control animals shows (with two exceptions, Experiments 4 and 6, Table II) that *all the naturally nephropathic animals were rendered anuric by the anesthetic in one-half hour after the anesthetic was administered.* At this period in the experiments the table shows that the anesthetic had induced a rapid depletion in the alkali reserve of all the naturally nephropathic animals which had become acutely anuric, while in the animals which at this period remained diuretic the alkali reserve had either undergone no change from the normal reading prior to the anesthetic or the reduction in the alkali reserve was not below 8.05. For example, the naturally nephropathic animal of Experiment 4 remained diuretic following the anesthetic and showed only a slight variation in the alkali reserve reading, 8.1 to 8.05. The animal of Experiment 6, which also remained diuretic, showed no change in the alkali reserve. The reading was 8 before and after the development of an anesthesia. The naturally nephropathic animals which became rapidly anuric show a depletion in the alkali reserve. The animal of Experiment 3 showed a reduction in the reserve alkali from 8.15 to 8, while in the animal of Experiment 8 the reserve alkali was reduced by the anesthetic from a normal reading of 8 to 7.9.

At this period of the experiments, the end of the first half hour, the functional response of the kidney was investigated by giving the animals caffein, theobromin, or pituitrin. A study of Table II shows these substances, in the animals in which the anesthetic had induced a rapid depletion of the alkali reserve of the blood, to be of no diuretic value. The animals remained anuric. In the animal of Experiment 6, in which there had occurred no change in the alkali reserve from the normal reading, theobromin induced a free diuresis, the output of urine increasing from 2 to 10 drops per minute. In the animal of Experiment 4 in which the anesthetic had brought

TABLE II.

Toxic Effect of an Anesthetic on the Functional Capacity of Normal and Naturally Nephropathic Kidneys.

Experiment Number	Anesthetic (Grehant's)	Urine per min.	pH ½ hr. after anesthetic	R. pH ½ hr. after anesthetic	Urine per min.	Diuretic	Urine per min.	pH 1 hr. after anesthetic	R. pH 1 hr. after anesthetic	Diuretic	Urine per min.	pH 1½ hrs. after anesthetic	R. pH 1½ hrs. after anesthetic	Carbon dioxid 1½ hrs. after anesthetic	Urine per min.	Fat in renal epithelium
	per cent.	*gtt.*			*gt*		*gtt.*				*gtt.*			*mm.*	*gtt.*	
1 (control)	60	2	7.45	8.0	2	Theobromin 1%	5	7.45	8.0	Pituitrin 0.5 cc.	21	7.35	8.0	36	3	Tr.
2 (control)	60	1	7.4	8.1	2	Caffein 1%	5	7.4	8.1	Glucose sol. 20%	26	7.4	8.1	39	6	Tr.
3	60	0	7.45	8.0	0	Pituitrin 0.5 cc.	0	7.4	7.9	Urea sol. 0.9%	0	7.1	7.8	19	0	L.*
4	60	2	7.4	8.05	0	Caffein 1%	0	7.3	7.9	Urea sol. 0.9%	0	7.25	7.85	22	0	L.*
5	60	0	7.45	7.8	0	Theobromin 1%	0	Not made	Not made	Glucose sol. 20%	0	7.35	7.85	Not made	0	L.*
6	60	2	7.35	8.0	2	Theobromin 1%	10	7.4	7.9	Theobromin 1%	0	7.25	7.85	21	0	L.*
7	60	0	7.3	8.0	0	Caffein 1%	0	7.35	7.9	Theobromin 1%	0	7.2	7.8	20	0	L.*
8	60	0	7.4	7.9	0	Theobromin 1%	0	7.4	7.9	Theobromin 1%	0	7.3	7.85	20	0	L.*
9	60	0	7.2	7.9	0	Caffein 1%	0	7.4	7.9	Urea sol. 0.9%	0	7.35	7.8	21	0	L.*
10	60	0	7.35	7.9	0	Theobromin 1%	0	7.4	7.8	Theobromin 1%	0	7.3	7.6	18	0	V. L.
11	60	0	7.4	8.0	0	Pituitrin 0.5 cc.	0	7.35	7.9	Urea sol. 0.9%	0	7.15	7.45	10	0	V. L.

*L., indicates large amount; V. L., very large amount.

about a reduction in the alkali reserve from 8.1 to 8.05 caffein was of no diuretic value.

At the end of the first hour of the anesthesia all the naturally nephropathic animals had become anuric. The alkali reserve of the blood had been reduced to 7.9 in all the animals except the dog of Experiment 10. The reserve alkali reading for this animal was 7.8. At this period of the experiment the functional response of the kidney was again tested by employing as diuretics theobromin, or solutions of urea and glucose. The kidneys of the naturally nephropathic animals were non-responsive to these substances which in the control animals had induced a marked diuretic effect. The anuria which has been associated with the development of an acid intoxication on the part of the anesthetized naturally nephropathic animals was unaffected by these diuretic solutions.

The experiments were continued for the third half hour period. During this time the animals remained anuric and the reserve alkali of the blood showed a progressive decrease in all the animals. At the termination of the experiments, 1½ hours after the first observations had been made, the reserve alkali readings for all the naturally nephropathic animals varied from a maximum reading of 7.85 to the extremely low reading of 7.45. The determinations of carbon dioxid tension in alveolar air at the close of the experiments varied between 22 and 10 mm. and showed the usual correlation with determinations of the alkali reserve of the blood.

In view of the previously mentioned observation that old animals were more susceptible to agents which induced an acid intoxication than were young animals, it is interesting to note that the two oldest naturally nephropathic animals gave evidence of having developed the severest acid intoxication. The animal of Experiment 10, 12 years old, had at the termination of the experiment an alkali reserve of 7.6 and a tension of alveolar air carbon dioxid of 18 mm., while the animal of Experiment 11, 13 years and 1 month old, had a reserve alkali of only 7.45 and a tension of alveolar air carbon dioxid of 10 mm.

The histological study of the kidneys of the naturally nephropathic animals after the establishment of an anuria by Gréhant's anesthetic has not shown any acute degenerative change or other evidence of vascular injury to the glomeruli. The capillary tufts usually fill the capsular space unless their distention has been prevented by a formation of connective tissue. The characteristic and constant change which is induced by the anesthetic is an acute swelling, vacuolation, and necrosis of the epithelium of the convoluted tubules, and a rapid accumulation of stainable fat in the ascending limbs of Henle's loops. Fatty degeneration of a slight degree is occasionally seen in the degenerating convoluted tubule epithelium. The amount of stainable fat in the epithelium has shown a relation with the degree of acid intoxication in the various animals. The animals which have shown the greatest depletion in their alkali reserve and the lowest tension of carbon dioxid in alveolar air have also shown the greatest accumulation of fat in the degenerated epithelium, especially the epithelium of Henle's loops (Figs. 1 and 2).

DISCUSSION.

DURING THE PAST 10 years numerous investigations have been concerned with the occurrence and significance of an acid intoxication in the acute and chronic nephropathies. As early as 1888 von Jaksch[15] noted a decrease in the alkalinity of the blood in uremia and this observation was confirmed in 1898 by Brandenburg.[16] Von Hösslin[17] in 1909 noted in certain of the nephropathies a definite relation betwen the acidity of the urine and the amount of albumin and number of casts, and in a later paper[18] after observing that very large amounts of alkali were necessary to reduce the acidity of the urine in nephritics, recommended rather indiscriminately the use of an alkali as a therapeutic measure. In 1912 Sellards,[19] employing his alkaline tolerance test in a

15. von Jaksch, R.: Ueber die Alkalescenz des Blutes bei Krankheiten, Z. klin. Med., 1888, Vol. xiii, 350.

16. Brandenburg, K.: Ueber die Alkalescenz des Blutes, Z. klin. Med., 1899, Vol. xxxvi, 267.

17. von Hosslin, R.: Ueber die Abhängigkeit der Albuminurie vom Säuregehalt des Urins, Münch. med. Woch., 1909, Vol. lvi, 1673.

18. von Hosslin: Ueber die Abhängigkeit der Albuminurie vom Säuregrad des Urins und über den Einfluss dere Alkalizufuhr auf Acidität, Albuminurie, Diurese und Chloridausscheidung, sowie auf das Harnammoniak, Deutsch. Arch. klin. Med., 1912, Vol. cv, 147.

19. Sellards, A. W.: The Determination of the Equilibrium in the Human Body Between Acids and Bases With Especial Reference to Acidosis and Nephropathies. Bull. Johns Hopkins Hosp., 1912, Vol. xxiii, 289.

group of nephropathies, noted a retention of bicarbonate in the acute nephropathies with uremia, and at about the same time Porges and Leimdörfer.[20] using determinations of carbon dioxid tension as an index of an acid intoxication, concluded that there occurred in general a reduction of carbon dioxid tension parallel to the symptoms of uremia. The work of Straub and Schlayer[21] which was confirmed by Barcroft[22] and his pupils has apparently established the fact that in the type of acute kidney injury characterized by the symptom complex uremia, there is a direct acute and chronic nephropathies which have not developed symptoms of uremia and whether or not when such an intoxication occurs in these cases it should be considered as a retention acidosis due to the kidney injury or whether it should be looked upon as the cause of the renal injury. Both Sellards[23] and Peabody[24] in their studies of the chronic nephropathies reach the conclusion that the acid intoxication developing in these conditions is a retention acidosis and that the accumulation of non-volatile acids is not responsible for the kidney injury.

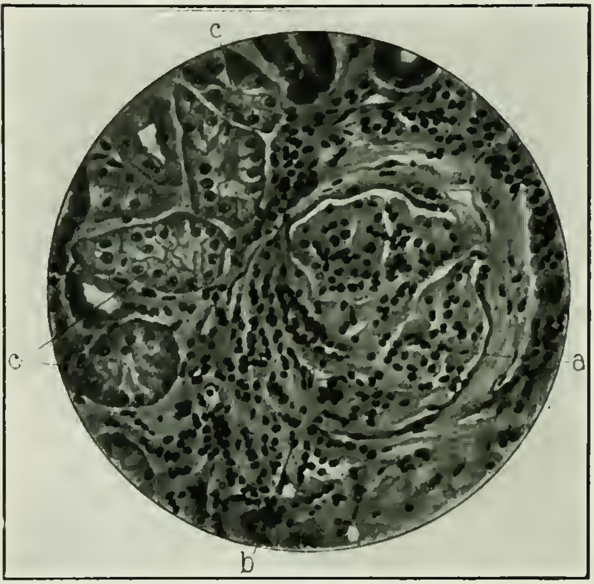

Figure 1.

Figure 2.

Fig. 1. Camera lucida drawing, Leitz oc. 2, obj. 6. The figure is from the kidney of the naturally nephropathic animal of Experiment 5, Table II. The glomerulus, *a*, has been to a large extent converted into a mass of connective tissue. The capillaries of the glomerulus have become obliterated and adherent to the thickened capsule. Surrounding the capsule is an area, *b*, of periglomerular fibrosis. At *c* is shown the acutely swollen and vacuolated convoluted tubule epithelium which is becoming necrotic. This animal after becoming anesthetized developed an acute acid intoxication, became anuric, and failed to show any diuretic effect from theobromin or a solution of glucose.

Fig. 2. Camera lucida drawing, Leitz oc. 2, obj. 6. The figure is from the kidney of the naturally nephropathic animal of Experiment 11, Table II. The glomeruli at *a* show both a capsular and an intracapillary formation of connective tissue. The smaller of the two glomeruli has undergone a partial hyaline degeneration. At *b* the thickening of the capsule is marked. At *c* is shown the acutely swollen convoluted tubule epithelium which is beginning to undergo necrosis. Very early during the anesthesia this animal developed an acute acid intoxication, became anuric, and failed to show any diuretic effect from either pituitrin or theobromin.

connection between the uremic manifestations and an acid intoxication.

The question which is still undecided is concerned with the association of an acid intoxication in those

20. Porges, O., and Leimdoerfer, A.: Ueber die Kohlensäurespannung des Blutes in pathologischen Zuständen. III Mitteilung. Ueber die Kohlensäurespannung bei Nierenerkrankungen, Z. klin. Med., 1913, Vol. lxxvii, 464.

21. Straub, H., and Schlayer: Die Urämie eine Säurevergiftung, Munch. med Woch., 1912, Vol. lix, 569.

22. Barcroft, J.: The Respiratory Function of the Blood. Cambridge, 1914.

An analysis of the experiments which have been presented in the present study show that animals may have a severe type of chronic kidney injury that is largely localized in the glomeruli without developing an acid intoxication

23. Sellards, A. W.: The Essential Features of Acidosis and Their Occurrence in Chronic Renal Disease. Bull. Johns Hopkins Hosp., 1914, Vol. xxv, 141.

24. Peabody, F. W.: Clinical Studies on the Respiration. II. The Acidosis of Chronic Nephritis. Arch. Int. Med., 1915, Vol. xvi, 955.

which can be detected by a depletion in the alkali reserve of the blood or by a reduction in the tension of alveolar air carbon dioxid. These animals show a slight retention of blood urea and a moderate reduction in the output of phenolsulphonephthalein. The minimum output of the dye in a 2-hour period for the naturally nephropathic animals has been 52 per cent. The kidneys of these animals show an epithelial element which is well preserved histologically and does not show any acute degenerative change. When these animals are anesthetized their response to the anesthetic as compared with normal animals shows the acid-base equilibrium of the naturally nephropathic animals to be clearly unstable, for these animals rapidly develop an acid intoxication while the control animals maintain their normal acid-base equilibrium. Furthermore, when the acid-base equilibrium of these naturally nephropathic animals is only slightly altered in the direction of an accumulation of acid ions the animals become anuric and fail to respond to a variety of diuretic substances. In the control animals which are able to maintain their normal acid-base equilibrium during the period of anesthesia these diuretic substances induce a marked increase in the formation of urine. The development of the anuria by the nephropathic animals during the period of anesthesia which coincides with the occurrence of the acid intoxication has been constantly associated with an acute degeneration of the convoluted tubule epithelium and without the development of any acute injury to the vascular tissue of the kidney.

From these experiments it would appear that in the naturally acquired kidney injury of the dog in which the chronic pathology is largely confined to the glomeruli, the injury is not due to an acid intoxication. The experiments furthermore show that when such a kidney is subjected to an agent which leads to the formation and accumulation in the blood of acid bodies, the epithelium rapidly degenerates, and that with this degeneration the functional capacity of the kidney is arrested.

CONCLUSIONS.

1. The naturally acquired chronic glomerulonephropathies of the dog are not due to an acid intoxication.

2. Such an injury renders the acid-base equilibrium of the animal unstable and susceptible to an agent such as an anesthetic which tends to induce an acid intoxication.

3. When naturally nephropathic animals are anesthetized by Gréhant's anesthetic, the principal anesthetic ingredient of which is chloroform, the animals develop an acid intoxication, and become anuric and non-responsive to diuretic substances.

4. The development of the anuria has been constantly associated with swelling, vacuolation, and necrosis of the convoluted tubule epithelium.

5. In the kidneys of these animals there occurs an accumulation of fat which is largely confined to the ascending limbs of Henle's loops and which shows a quantitative relation with the degree of acid intoxication.

PART II.

IN PART I OF the present investigation, which was concerned with a study of the acid-base equilibrium of the blood in naturally nephropathic animals during the course of an anesthesia and also with the functional capacity of the kidneys of these animals, there was shown to be a relation between the depletion of the blood of its alkali reserve with the functional response of the kidney to various diuretic substances and to the development of an anuria. Naturally nephropathic animals when contrasted with normal animals as controls were shown to have an unstable acid-base equilibrium, and when the mechanism which controls this equilibrium was subjected to the action of an agent such as chloroform which tends to induce an acid intoxication, the naturally nephropathic animals very rapidly developed such an intoxication, and became anuric. The normal animals gave no evidence of an acid intoxication and in these animals the formation of urine was unaffected by the anesthetic.

In two recent papers,[1,2] which were concerned with the acute nephropathy induced in the dog by uranium I have been able to show not only an association between the degree of kidney injury and the severity of the acid intoxication induced by this metal, but have also shown that the intravenous use of an alkali in these animals would protect the kidney against the toxic effect of uranium and increase the efficiency of various diuretic substances. The first of these observations has been recently confirmed by the work of Goto.[3]

In the present study, Part II, an investigation will be made of the ability of an alkali to protect the naturaly nephropathic kidney against Gréhant's anesthetic and to ascertain whether or not a sufficient degree of protection is obtained to enable the kidney to retain its responsiveness to diuretic solutions.

EXPERIMENTAL.

IN THIS STUDY a technic similar to that employed in Part I has been followed. Twenty-eight naturally nephropathic animals have been used in the investigation. Ten of these animals were used as control experiments, while the remaining eighteen animals were given an alkaline solution and furnished the basis for the deductions concerning the ability of an alkali to protect the kidney against the toxic effect of an anesthetic.

OBSERVATIONS ON NATURALLY NEPHROPATHIC ANIMALS PRIOR TO PROTECTING THE KIDNEY AGAINST THE ANESTHETIC BY SODIUM CARBONATE.

THE OBSERVATIONS ON BOTH GROUPS of animals prior to an anesthetic are included in Table I. In this table observations are recorded on two of the control animals, Experiments 1 and 2, and four of the animals which received the alkaline injection, Experiments 3 to 6. The table shows all the animals to be freely diuretic on the final day of observation prior to the use of an anesthetic. All the animals were naturally nephropathic. The urine contained albumin which varied in amount from a mere trace to 1.5 gm. per liter. Casts were present in the urine from all the animals. The urine of only one animal, Experiment 4, showed the presence of acetone bodies. The urine from this animal contained both acetone and diacetic acid. The hydrogen ion content of the blood has varied from 7.35 to 7.5 As indicated in Part I of these studies the readings do not give a true expression of the non-volatile acid content of the blood. The reserve alkali of the blood in these naturally nephropathic animals has varied between a minimum of 8 and a maximum of 8.1. The readings correlate with the determinations of alveolar air carbon dioxid which show a variation from 39 to 42 mm. These observations substantiate the conclusion made in the previous study, that the naturally nephropathic dog with kidney changes largely confined to the glomeruli does not show a depletion in the alkali reserve of the blood.

The renal function test in these animals shows a reduction in the output of phenolsulphonephthalein. The percentage elimination in a 2-hour period has varied from 54 to 64 per cent. In all the animals there is an increase in the percentage of blood urea. The animal with the highest percentage of blood urea has shown the greatest reduction in the elimination of phenolsulphonephthalein (Experiment 6, Table I). The foregoing account of observations made on naturally nephropathic animals used in this study, confirms in detail the observations made on the naturally nephropathic animals which were employed in Part I.

On the day of experiment the animals were

1. MacNider, W. deB.: The Inhibition of the Toxicity of Uranium Nitrate by Sodium Carbonate, and the Protection of the Kidney Acutely Nephropathic From Uranium From the Toxic Action of an Anesthetic by Sodium Carbonate. J. Exp. Med., 1916, Vol. xxiii, 171.

2. MacNider: The Efficiency of Various Diuretics in the Acutely Nephropathic Kidney, Protected and Unprotected by Sodium Carbonate. II, J. Exp. Med., 1917, Vol. xxvi, 19.

3. Goto, K.: A Study of the Acidosis, Blood Urea, and Plasma Chlorides in Uranium Nephritis in the Dog, and of the Protective Action of Sodium Bicarbonate. J. Exp. Med., 1917, Vol. xxv, 693.

given 300 cc. of water by stomach tube. Three hours later under local anesthesia from a 2 per cent. solution of cocain the control animals were given intravenously 25 cc. per kilo of 0.9 per cent. sodium chlorid solution; while the animals which were to receive the protection against the anesthetic were given intravenously 25 cc. per kilo of a solution of sodium carbonate equimolecular with 0.9 per cent. sodium chlorid. The animals were then anesthetized by Gréhant's anesthetic in 60 per cent. strength. One hour after giving the anesthetic the first observations were made on the acid-base equilibrium of the blood, the formation of urine, and the response of the kidney to various diuretic substances. The details of these observations are recorded in Table II.

ment 2, was given pituitrin. The animals remained anuric and non-responsive to these diuretic substances. Half an hour after giving these solutions the alkali reserve of the blood in both the control animals was reduced to 7.85. During this period no urine had been formed. Two hours after the commencement of the anesthesia the control animal of Experiment 1 was given 10 cc. per kilo of a 0.9 per cent. solution of urea, while the second control animal was given a 1 per cent. solution of theobromin. To these diuretic solutions there was no response. The blood at this stage of the experiments showed a further depletion of reserve alkali. The alkali reserve reading for the animal of Experiment 1 was 7.7, while the reading for the second control animal, Experiment 2, was 7.6. The tension of

TABLE I.

Observations on Naturally Nephropathic Animals Prior to Protecting the Kidney against the Anesthetic by Sodium Carbonate.

Experiment number	Age of animal	Weight	Water in 24 hrs.	Urine on day of experiment	Albumin and casts	Acetone per 100 cc.	Diacetic acid per 100 cc.	pH	R. pH	Carbon dioxid	Blood urea	Phenol-sulphonephthalein
	yrs.	*kg.*	*cc.*	*cc.*		*mg.*	*mg.*			*mm.*	*per cent.*	*per cent.*
1 (control)	6	12.4	500	498	Tr. Few casts	0	0	7.45	8.0	40	0.014	34
2 (control)	10 yrs. and 3 mos.	17.4	500	835	0.9 gm. Few casts	0	0	7.5	8.1	42	0.016	58
3	6	15.65	500	478	Tr. Few casts	0	0	7.35	8.1	40	0.015	56
4	11	17.4	500	508	Tr. Few casts	11.3139	3.6456	7.4	8.0	39	0.018	64
5	13 yrs. and 2 mos.	7.85	500	611	1.5 gm. Few casts	0	0	7.4	8.05	40	Not made	
6	15	18.9	500	515	Tr. Few casts	0	0	7.5	8.0	38	0.028	51

A study of the control animals of Table II which received prior to the anesthetic a solution of sodium chlorid shows a response on the part of these animals to the anesthetic similar to that obtained with all the naturally nephropathic animals used in Part I of these studies. The animals show a rapid depletion in the alkali reserve of the blood so that by the end of the first hour of the experiments the reserve alkali readings have been reduced to 7.9. At this stage of the experiments both the control animals, Experiments 1 and 2, had become anuric. The animal of Experiment 1 was given a solution of theobromin, while the second control animal, Experi-

alveolar air carbon dioxid showed a proportionate reduction. The tension in Experiment 1 was reduced to 19 mm., while in Experiment 2 the tension was reduced to 15 mm. At this stage of the experiments, 2 hours after the commencement of the anesthesia, the kidneys were removed and the experiments terminated.

The histological study of the kidneys of these naturally nephropathic animals which received a solution of sodium chlorid and served as control experiments shows changes similar in character to those described for the naturally nephropathic animals of Part I. The kidneys show a chronic glomerulonephropathy. The acute changes which have been induced in the kidneys by the anesthetic and which have been associated with the development of an acid intoxication and an anuria, consists in an acute swelling and necrosis of the convoluted tubule epithelium and the deposition of large amounts of stainable fat in the ascending limbs of Henle's loops.

The following conclusions are permissible from the observations on naturally nephropathic animals which have served as control experiments: (1) A 0.9 per cent. solution of sodium chlorid given to a naturally nephropathic animal prior to an anesthetic has no effect in protecting the animals against an acid intoxication resulting from the anesthetic. (2) With a blood hydremic from such a solution various diuretic substances as pituitrin, theobromin, and solutions of urea are ineffective as diuretics.

PROTECTION OF THE NATURALLY NEPHROPATHIC KIDNEY AGAINST THE TOXIC EFFECT OF AN ANESTHETIC BY SODIUM CARBONATE.

A STUDY OF THE animals of Table II, Experiments 3 to 6, which received solutions of sodium carbonate, shows the effect of such solutions on the acid-base equilibrium of the blood of naturally nephropathic animals and the efficiency of the solution in protecting the kidney against the toxic effect of the anesthetic. These experiments when compared with the control animals demonstrate that the use of the carbonate solution conferred sufficient protection against the anesthetic to prevent the animals from becoming anuric during the development of an anesthesia. As will be seen from a study of Table II, all the control animals at this early period of the anesthesia had become anuric.

TABLE II.

Protection of the Naturally Nephropathic Kidney Against the Toxic Effect of an Anesthetic by Sodium Carbonate.

Experiment Number	Na_2CO_3 or NaCl solution	Anesthetic (Gréhant's)	Urine per min.	pH 1 hr. after anesthetic	R. pH 1 hr. after anesthetic	Urine 1 hr. after anesthetic	Diuretic	Urine per min.	pH 1½ hrs. after anesthetic	R. pH 1½ hrs. after anesthetic	Urine 1½ hrs. after anesthetic	Diuretic	Urine per min.	pH 2 hrs. after anesthetic	R. pH 2 hrs. after anesthetic	Carbon dioxid 2 hrs. after anesthetic	Urine per min.	Fat in renal epithelium
		per cent.	*gtt.*			*gtt.*		*gtt.*			*gtt.*		*gtt.*			*mm.*	*gtt.*	
1 (control)	NaCl sol. 25 cc. per kg.	60	0	7.35	7.9	0	Theobromin 1%	0	7.35	7.85	0	Urea sol. 0.9%	0	7.2	7.7	19	0	V.L.*
2 (control)	NaCl sol. 25 cc. per kg.	60	0	7.4	7.9	0	Pituitrin 0.5 cc.	0	7.25	7.85	0	Theobromin 1%	0	7.2	7.6	15	0	V.L.*
3	Na_2CO_3 sol. 25 cc. per kg.	60	2	7.65	8.3	2	Pituitrin 0.5 cc.	3	7.4	8.2	1	Theobromin 1%	1	7.35	8.0	32	2	Tr.
4	Na_2CO_3 sol. 25 cc. per kg.	60	3	7.5	8.25	2	Caffein 1%	2	7.3	8.0	0-1	Glucose sol. 20%	0	7.3	7.85	24	0	L.
5	Na_2CO_3 sol. 25 cc. per kg.	60	1	7.5	8.3	1	Pituitrin 0.5 cc.	2	7.4	8.2	1	Urea sol. 0.9%	1	7.3	7.95	34	2	Tr.
6	Na_2CO_3 sol. 25 cc. per kg.	60	1	7.65	8.3	1	Pituitrin 0.5 cc.	1	7.4	8.1	1	Urea sol. 0.9%	0	7.35	7.85	21	0	L.

*V. L., indicates very large amount; L., large amount.

One hour after the commencement of the anesthetic the carbonate animals continued to remain diuretic, the flow of urine in the respective animals varying between one to two drops per minute. The alkali reserve of the blood at this period of observation as a result of the use of the carbonate solution has shown an increase in alkali above the normal. The readings vary from 8.25 to 8.3. With the alkali reserve increased to this degree the animals were given either a solution of caffein or pituitrin to test the functional response of the kidney. Two of the animals, Experiments 3 and 5, responded to these diuretics by an increased formation of urine, while the two remaining animals, Experiments 4 and 6, though failing to respond to the diuretics by an increase in the formation of urine, had a flow of urine of the same rate that existed before the use of a diuretic solution.

At the second period of observation, 1½ hours after the commencement of the anesthesia, the two animals of Experiments 3 and 5, which had shown a diuretic effect from pituitrin showed but a slight reduction in their alkali reserve and remained diuretic. In these animals the alkali reserve had only been reduced from 8.3 to 8.2. The two animals of Experiments 4 and 6, which had shown no diuretic effect from either caffein or pituitrin, showed a reduction in the alkali reserve of from 8.25 to 8 and from 8.3 to 8.1. These variations in the rapidity with which the alkali reserve is used up by the anesthetized animals would indicate that the animals which continued to form urine, but which showed no increase in the output of urine from the diuretic solutions were forming during the anesthesia a larger amount of acid than were the animals which not only remained diuretic, but retained their responsiveness to diuretic substances. The tolerance for an alkali as indicated by the rapidity with which the alkali reserve is depleted is greater in the animals non-responsive to diuretics than in the animals in which the use of the diuretic solutions resulted in an increased formation of urine.

At the final period of observation, 2 hours after the commencement of the anesthesia, two of the animals which had received the carbonate protection prior to the anesthetic, remained diuretic (Experiments 3 and 5). These animals had a reserve alkali reading of 8 and 7.95. The tension of alveolar air carbon dioxid for the first animal was 32 mm. and for the second animal 34 mm. The animals of Experiments 4 and 6, which also received the carbonate protection, at this stage of the experiment showed a rapid depletion in their alkali reserve and an associated decrease in the tension of alveolar air carbon dioxid. The animal of Experiment 4 had an alkali reserve of 7.85 and a tension of alveolar air carbon dioxid of 24 mm. The readings for the animal of Experiment 6 were practically the same. The alkali reserve had been reduced to 7.85, and the carbon dioxid tension to 21 mm. Both of these animals had become anuric.

At this stage of the experiments the animals were again given diuretic solutions. The animals of Experiments 3 and 5 were given respectively a solution of theobromin and a 0.9 per cent. solution of urea. To these diuretic substances the animals were responsive. In both experiments the output of urine was increased from one to two drops per minute. The animals of Experiments 4 and 6, which had become anuric, were given either a 20 per cent. solution of glucose or a 0.9 per cent. solution of urea. These solutions were of no diuretic value. The animals remained anuric.

The histological examination of the kidneys of the animals which have been successfully protected against the toxic effect of the anesthetic by a solution of sodium carbonate shows the type of chronic glomerular pathology which has been previously described. The epithelium of the convoluted tubules shows only a slight degree of swelling and albuminous degeneration. The epithelium is not vacuolated, and the cells show no advanced degenerative changes indicative of a beginning necrosis. The cell cytoplasm stains uniformly and the nuclei take an intense stain (Figs. 1 and 2).

The kidneys of the animals which have shown an early protection against the anesthetic but which later in the experiments have shown a lack of protection by failing to respond to diuretic solutions and by finally becoming anuric, have like the control animals developed an acute swelling, vacuolation, and necrosis of the convoluted tubule epithelium, and have shown a large amount of fat in the ascending limbs of Henle's loops (Fig. 3).

DISCUSSION.

AN ANALYSIS OF THE results obtained in the eighteen naturally nephropathic animals which received a solution of sodium carbonate in an attempt to protect them against the toxic effect of an anesthetic shows that based upon the efficiency of the protection the animals may be divided into two groups. All the animals for an hour after the development of a state of anesthesia remained diuretic. This is in striking contrast to the control animals that received the solutions of sodium chlorid. At this period of the experiments all the latter animals had become anuric. After this first hour period, however, the animals which received the carbonate solution while remaining diuretic show a variation in the degree of protection conferred by the carbonate in that twelve of the eighteen animals which constitute one group were responsive to diuretic substances and showed an increased formation of urine when the solutions were employed, while four of the total number of animals representing the second group gave no diuretic response to the same diuretic solutions. It is

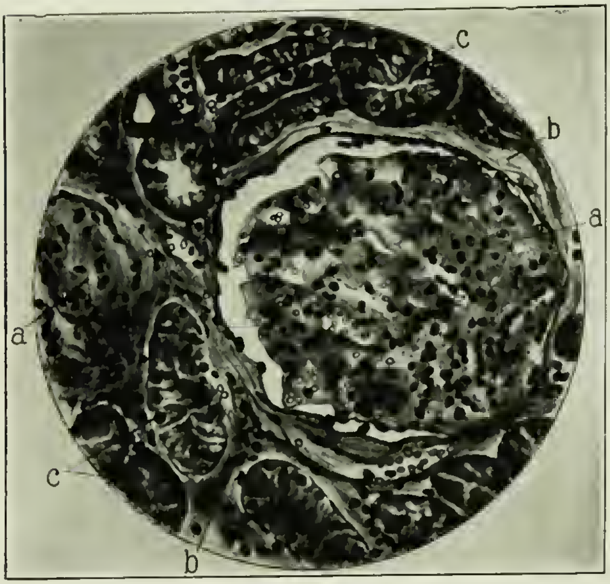

Figure 1.

Figure 2.

FIG. 1. Camera lucida drawing, Leitz oc. 2, obj. 6. The figure is from the kidney of Experiment 3, Table 11. It shows at *a*, a glomerulus greatly increased in size from the formation of connective tissue. The capsule is but slightly thickened. The chronic glomerular pathology was mainly of the intracapillary type of change. At *b* are shown convoluted tubules the epithelium of which stains normally and shows no swelling. At *c* are shown tubules the epithelium of which is slightly swollen and stains imperfectly. The kidneys of this animal were successfully protected against the anesthetic by a solution of sodium carbonate. The kidneys were responsive to both pituitrin and theobromin.

FIG. 2. Camera lucida drawing, Zeiss oc. 3, obj. 6. The figure is from the kidney of Experiment 5, Table 11. It shows at *a* the glomerulus which is increased in size from the formation of connective tissue. Many of the capillary loops have been obliterated. At *b* is shown the thickened capsule. At *c* is shown a dense mass of periglomerular connective tissue. The epithelium of the convoluted tubules at *d* shows but slight swelling. The cytoplasm and nuclei of the cells stain well. At *e* are shown two convoluted tubules in which the epithelium is increased in size without becoming vacuolated. The kidneys of this animal were successfully protected against the anesthetic by sodium carbonate. The animal remained diuretic to pituitrin and a solution of urea.

important to note that at this period of the experiments the reserve alkali of these animals had undergone a depletion, yet the depletion was not below the point of a normal hydroxyl ion content. We cannot, therefore, ascribe this lack of functional response to an acid intoxication in the sense that a sufficiently large amount of hydrogen ions had been liberated during the anesthesia to reduce the alkali reserve below the point of normality. During the remainder of the experiments these animals which early in the anesthesia failed to show an increase in the formation of urine from diuretic substances, show a rapid depletion in their alkali reserve, and become anuric.

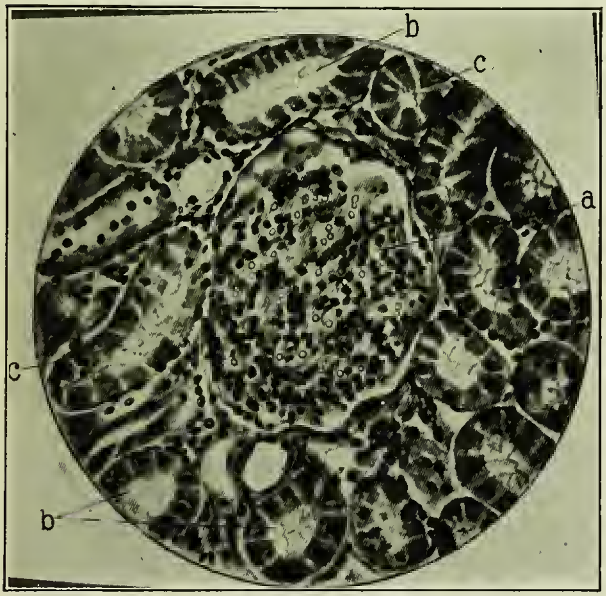

Figure 3.

Fig. 3. Camera lucida drawing, Leitz oc. 2, obj. 6. The figure is from the kidney of Experiment 6, Table II. The figure shows at *a* the glomerulus which is greatly increased in size from the formation of connective tissue. Many of the capillary loops have become obliterated. The tuft of capillaries is adherent to the greatly thickened capsule *b*. The convoluted tubules at c show an acute swelling, vacuolar degeneration, and a beginning necrosis. The kidneys of this animal were imperfectly protected against the anesthetic by a solution of sodium carbonate. The alkali reserve of the blood was rapidly depleted to a reading of 7.85, and the animal became anuric and failed to show a diuretic effect from pituitrin and a solution of urea.

The group of animals that received the carbonate solution and were effectively protected against the toxic effect of the anesthetic maintained for a longer period during the anesthesia the increase in the hydroxyl ion content of the blood. At the end of the experiments these animals showed a reserve alkali which was not depleted below 7.95. During the anesthesia and at the termination of the experiments the animals were not only forming urine but they were responsive to diuretic substances.

The present investigation has shown that naturally nephropathic animals may be protected in varying degrees against the toxic effect of an anesthetic by the use of an alkaline solution and that a failure to protect such a kidney during an anesthesia is associated with a rapid depletion of the blood of its alkali reserve and the development of an acid intoxication. This change in the acid-base equilibrium of the blood in these animals has in turn been associated with an acute swelling and necrosis, particularly of the convoluted tubule epithelium, and the development of an anuria. From this observation there is no evidence which would justify the conclusion that the increase in hydrogen ions acting as such upon the epithelial element of the kidney is the cause for the acute swelling and necrosis of the epithelium. The actual way in which an increase of hydrogen ions leads to an injury of the epithelium and the mode of action of an alkaline solution in deferring or preventing this injury remains a problem for future solution.

CONCLUSIONS.

1. A 0.9 per cent. solution of sodium chlorid when given intravenously to anesthetized naturally nephropathic animals is not effective in preventing the development of an acid intoxication and the associated kidney injury.

2. A solution of sodium carbonate equimolecular with a 0.9 per cent. solution of sodium chlorid when given intravenously to anesthetized naturally nephropathic animals confers a variable degree of protection to the kidney.

3. The degree of protection conferred by the alkaline solution is associated with the ability of the solution to maintain a normal acid-base equilibrium of the blood of the anesthetized animal.

WORKING IN THE Department of Pathology of the University of Pennsylvania and the Clinics of the Lankenau Hospital, Philadelphia, S. P. Reimann and G. H. Bloom have recorded the results of their studies in the decreased plasma bicarbonate during anesthesia and its cause, in the Journal of Biological Chemistry, October, 1918. By way of introduction to their own studies reported to the Pathological Society of Philadelphia, 1918, and to the American Association of Anesthetists, 1919, these research workers remind us that:

Caldwell and Cleveland,[1] Cannon,[2] and others have observed that anesthesia and operation are followed by a decrease in the bicarbonate content of the blood plasma. The cause of the decrease has not been demonstrated. On the basis of present knowledge, three hypothetical explanations may be proposed.

(1) Since acetone bodies are demonstrated in the urine, [1, 3, 4] sufficient quantities of *B*-hydroxybutyric and acetoacetic acids may be formed to decompose the bicarbonate that disappears. In this case the acetone bodies might be retained in the body but they might also be excreted in the urine, taking with them the alkali with which they had combined in the body.

(2) Organic acids other than the acetone bodies may be formed and assist the latter in lowering the blood bicarbonate.

(3) The fall in bicarbonate may be due chiefly, not to any acids, but to the transfer of bicarbonate from plasma to body cells as a result of the increased ventilation during anesthesia. Artificially increased respiration has been recently shown by Henderson and his associates[5] to lower not only the free carbonic acid, but also the bicarbonate of the blood, the latter shifting from blood plasma to cells when the free carbonic acid is lowered below normal limits. In this special condition the blood bicarbonate is no longer a measure of the total body bicarbonate, and a lowering of the blood bicarbonate does not indicate a decrease in the alkaline reserve of the body.

The present work was undertaken to obtain data which would give some indication as to whether one of the above factors or a combination of them causes the decrease of the bicarbonate observed during anesthesia and operation. In case the increase of acetone bodies in the blood should prove sufficient to account alone for the fall in bicarbonate, the other two factors would be demonstrated to be of, at most, minor importance.

Accordingly, quantitative estimations of the *total acetone bodies* (acetone, acetoacetic acid, and *B*-hydroxybutyric acid) of the blood were made before and after operation in 60 patients from the clinic of Dr. John B. Deaver, to whom we express our thanks for his coöperation and for the clinical data. Bicarbonate determinations on the plasma were carried out at the same time.

TECHNIC.

ABOUT 20 CC. of blood were drawn a few hours before operation from a vein in the bend of the elbow, with due precautions to prevent stagnation. Powdered potassium oxalate was used to prevent clotting and paraffin oil to prevent escape of CO_2 in the sample for CO_2 estimation. For the latter, the blood was centrifuged immediately and the plasma saturated with a mixture of 5.5 per cent. CO_2 in air from a tank, and analyzed for CO_2 with the apparatus and according to the technic of Van Slyke.[6] Re-

1. CALDWELL, G. A., and CLEVELAND, M.: Surg., Gynec. and Obst., 1917, Vol. xxv, 22.
2. CANNON, W. B.: J. Am. Med. Assn., 1918, Vol. lxx; 531.
3. REICHER, K.: Z. klin. Med., 1908, Vol. lxv, 235.
4. BRADNER, M. R., and REIMANN, S. P.: Am. J. Med. Sc., 1915, Vol. cl, 727.
5. HENDERSON, Y., and HAGGARD, H. W.: J. Biol. Chem., 1918, Vol. xxxiii, 333, 345, 355, 365.
6. VAN SLYKE, D. D.: J. Biol. Chem., 1917, Vol. xxx, 347.

sults are expressed in cc. of CO_2 at 0° and 760 mm. pressure per 100 cc. of plasma. For the *total acetone body* determinations, 10 cc. of whole blood were analyzed by the method of Van Slyke and Fitz.[7] The results express the sum of acetone, acetoacetic acid, and *B*-hydroxybutyric acid in terms of mg. of acetone per 100 cc. of blood. The patient's clinical history was noted, the manner of taking the anesthetic, and the operation and findings were added. The duration of anesthesia was counted in minutes from the administration of the first drop until the gauze was removed, the open drop method of anesthesia being used. A second sample of blood was then obtained and subjected to the same analyses. Observations of the postoperative condition were the final steps. Ether was the anesthetic in all but one case, in which nitrous oxid was used.

Quantitative determinations of the ketone excretion in the urine were performed in twenty-eight cases by the technic of Van Slyke.[8] The quantities expressed are the amounts excreted in 24 hours after the last voiding, which was performed immediately before operation. They represent, therefore, the total amount excreted 24 hours after the beginning of anesthesia and operation.

The percentage of excretion of phenolsulphonephthalein was appended in a few cases.

Determinations of the catalase content of the blood were performed before and after operation in twenty-seven cases for purposes to be discussed below. The technic was the well known one of adding a standard amount of blood to a standard amount of hydrogen peroxid and collecting the evolved oxygen in an inverted burette during a standard time interval, 0.5 cc. of blood were used, 50 cc. of hydrogen peroxid plus about 200 cc. of water; the time was 10 minutes. The bottle containing the blood and hydrogen peroxid was placed in a water bath at 37° during the collection of the oxygen. Results are expressed in cc. of oxygen at 0° and 760 mm. pressure.

7. Van Slyke, D. D., and Fitz, R.: J. Biol. Chem., 1917, Vol. xxxii, 495.

8. Van Slyke: J. Biol. Chem., 1917, Vol. xxxii, 455.

Calculations of the theoretical decrease in CO_2 corresponding to the increase in ketones, calculated as acetone in M concentration, are incorporated in the results.

A very definite increase in the amounts of ketone bodies in the blood occurred during anesthesia and operation. (For normal figures, Van Slyke and Fitz[7] have given up to 1 to 2 mg. per 100 cc.) Many of our patients were young men in the best of health except for a hernia or varicocele, and some were operated to enable them to enlist in some branch of military service. Their average ketone content before operation was 17 mg. per 100 cc.

Only 10 of 60 patients or 16 per cent. showed a diminution of the CO_2 capacity to below 50 cc., and in only 1 case did it fall below 40 cc. above which Stillman, Van Slyke, Cullen, and Fitz[9] found no marked symptoms of acidosis *per se* in diabetes. Those of our patients who showed a CO_2 capacity even below 50 cc., however, showed a much higher percentage of post-operative symptoms, such as rapid pulse, restlessness, and gas pains, then the others.

Especial attention is drawn to one case, who had noticed a goiter for about a year, but had no other symptoms than the presence of a small swelling. On admission, the patient was somewhat nervous, but her pulse remained around 90 per minute until she was about to be carried to the operating room, when it reached 140, and she become obviously very much unsettled. Anesthesia lasted 54 minutes and was very smooth. Her pulse was then 170, but of good volume. For 3 days it remained from 120 to 160 and she appeared very toxic; on the 4th day she recovered from her toxic symptoms very rapidly, so that by the 5th day the prognosis was undoubtedly favorable, from having been extremely grave for 3 days and doubtful on the 4th. Her CO_2 capacity before operation, 42 cc., indicated an already existing acidosis and the fall of 13.9 cc., bringing her capacity to 28.1 cc., showed that her alkali was brought to a level which was indeed critical. Her ketones before operation were at the very high level of 103.7 mg., with an increase of 81.9 mg.

Women, according to the observers mentioned, excrete larger amounts of ketone bodies in their urine after operation than men. Their results are only very approximate on account of the

9. Stillman, E., Van Slyke, D. D., Cullen, G. E., and Fitz, R.: J. Biol. Chem., 1917, Vol. xxx, 405.

technic used.[10] The amounts in the blood and urine in our series are therefore interesting. Twenty-six of these patients were women and their average total acetone bodies in the blood was 21.1 mg., with an increase to 47.2 mg. The average content of the men was 16.4 mg. with an increase to 40.3 mg. The average fall in CO_2 in women was 16 cc.; in men, 18.5 cc. The data of excretion were obtained in only seven women; their average was 3.4 gm. in 24 hours. In twenty-one men, the average was 0.814 gm.

A number of patients with peritonitis from various causes were fasted for 1 to 3 days before operation. These might be expected to have a higher blood ketone on account of deprivation of food alone, but their average was 6.6 mg. The increase after anesthesia and operation, however, averaged 18.4 mg., the largest of any group. The fall in the CO_2 capacity averaged 17.6 cc.

Those who were given the anesthetic for less than 60 minutes showed an average fall of CO_2 capacity of 17.0 cc. and a rise of ketones of 23.4 mg. Those who received the anesthetic over 60 minutes showed a fall of CO_2 capacity of 14.4 cc., and a rise in ketones of 21.7 mg. Those under 30 minutes showed a fall in CO_2 capacity of 13.5 cc., and an increase in ketones of 13.2 mg.

From the standpoint of postoperative symptomatology, most of the patients recovered promptly and with few troubles. A few, however, were nauseated and vomited several times, and some were annoyed by gaseous distention. Their average fall in CO_2 capacity was 16.7 cc.; the average rise in ketones, 27.3 mg.

Other patients showed some postoperative restlessness with rapid pulse, though none in the series was actually shocked. The fall in CO_2 capacity of these was 17.5 cc., and the average increase in ketones was 38 mg., corresponding in molecular equivalent to a CO_2 change of 15 cc.

In the entire series of cases the average increase in total acetone bodies calculated as acetone was 25 mg. per 100 cc., or 0.0043 M in concentration, corresponding to a change in bicarbonate CO_2 of 9.6 cc. in 100 cc. of blood. The average observed fall in bicarbonate CO_2 was 15.9 cc. These figures indicate that the acetone bodies which appear in the blood are sufficient to account on the average for 60 per cent. of the observed fall in bicarbonate. They are, therefore, not the only factor, but as a rule, they are an important one in reducing the plasma bicarbonate during anesthesia and operation.

When cases are considered individually, the results show inconsistencies. In 13 of the 60 cases, the increase in acetone bodies equals or exceeds in molecular concentration the fall in bicarbonate. The case representing the extreme in this respect, showed an increase of 255 mg. of acetone bodies, corresponding to a decrease of 98 cc. of CO_2 per 100 cc. of blood, with an actual fall in plasma CO_2 of only 23 cc. In this case the greater part of the ketone acids must have been neutralized from sources other than the blood bicarbonates. We have no data to decide whether the alkali was ammonia or mineral alkali from the tissues.

The catalases of the blood are decreased after anesthesia according to Burge, Neill, and Ashman.[11] In about 78 per cent. of our cases, the catalases, as evidenced by the amount of oxygen liberated from hydrogen peroxide, were diminished, the diminution bearing no particular relationship to either the clinical findings or to our other analytical data. The duration of anesthesia does not show any relation to the fall in the catalase content. These determinations were made with the idea of the depression of oxidation theory of anesthesia in mind.

SUMMARY.

DETERMINATION OF THE total acetone bodies of the blood, the bicarbonate content of the plasma, and the catalases of the blood were performed before and after anesthesia and operation in a series of patients. Quantitative estimations of the total acetone body elimina-

10. Qualitative determinations of the urine by the sodium-nitroprussid and the ferric chlorid methods for ketones often yielded negative results, when quantitative estimations by the Van Slyke method yielded an appreciable precipitate.

11. Burge, W. E., Neill, A. J., and Ashman, R.: Am. J. Physiol., 1918, Vol. xlv, 388.

tions in the urine were made on a number of these patients.

The total acetone bodies of the blood were increased in each case. The bicarbonate content of the plasma was diminished. Catalases were diminished in 78 per cent. of the cases examined.

CONCLUSIONS.

1. Blood acetone bodies account for 20 to 100 per cent. of the bicarbonate fall observed, on the average for 60 per cent. Whether the remainder of the bicarbonate fall is due to acetone bodies that have been excreted and have carried alkali out of the body with them, or to the formation of other, as yet unidentified organic acids resulting from incomplete oxidation, or merely to a shift of bicarbonate from plasma to tissue cells under the influence of overstimulated respiration[5] has not been determined.

2. The conclusion of Caldwell and Cleveland is confirmed, that anesthesia and operation do not in most cases lower the plasma CO_2 to a point where acidosis is indicated.

3. In those cases in which this did occur, however, (15 per cent. of the total) postoperative symptoms were more intense.

4. The decrease in CO_2 capacity as a result of anesthesia and operation varied from 5 to 15 cc., occasionally more, per 100 cc. Consequently, the well known use of sodium bicarbonate before operation appears logical. It is suggested, however, that its use be controlled, *i. e.*, that it be administered only when the plasma CO_2 capacity before operation is less than about 58 cc., and that the dose be calculated from the plasma CO_2 as suggested by Palmer and Van Slyke.[12]

NOTE.—S. P. Reimann and his coworkers in the Departments of Pathology of the University of Pennsylvania Medical School and Lankenau Hospital are continuing their studies in acidosis, ketonosis and alkalosis in relation to anesthesia and operation and their data and results will appear in succeeding issues of the Year-Book.

12. PALMER, W. W., and VAN SLYKE, D. D.: J. Biol. Chem., 1917, Vol. xxxii, 499.

CONTINUING STUDIES in the respiratory regulation of the carbon dioxid capacity of the blood, Yandell Henderson and H. W. Haggard, of New Haven, Connecticut, working in the Physiological Laboratory of Yale Medical School and publishing their data in the Journal of Biological Chemistry, February, 1918, reiterate that:

In the light of present knowledge it appears probable that many, perhaps most, of the functional disturbances induced by anesthesia are due to the production of an abnormal CO_2 capacity (alkaline reserve) in the blood, or to deeper effects of which the CO_2 capacity is an index.

At present such effects are generally interpreted as *acidosis*. Our observations show that, at least under ether, they are of a very different origin.

Morriss[1] has shown that in patients under ether a lowering of the alkaline reserve of the plasma occurs. On the basis of some preliminary experiments on dogs Prince and the authors[2] have verified Morriss' observation and have obtained results indicating that the effect is due to the respiratory excitement induced by ether. An abnormally great amount of CO_2 is ventilated out of the blood by the excessive breathing and the CO_2 content is thus lowered. Sometimes when this blowing off has been very rapid the result is failure of respiration: apnea vera. When the blowing off is less rapid but is prolonged another change occurs which (as Prince first pointed out to us) is of a compensatory character. This consists in a decrease of the CO_2-combining power (alkaline reserve) of the blood. The simplest supposition upon which to explain it is that when the alka-

1. MORRISS, W. H.: J. Am. Med. Assn., 1917, Vol. lxviii, 1391.
2. HENDERSON, Y., PRINCE, A. L., and HAGGARD, H. W.: J. Am. Med. Assn., 1917, Vol. lxix, 965.

linity of the blood is abnormally increased by the blowing off of CO_2, alkali passes out of the blood into the tissues. As a result of these two processes both the CO_2 and the alkali in the blood are decreased, and the proportion of H_2CO_3:$NaHCO_3$ and consequently the C^H of the blood are much less decreased than would be the case if only the CO_2 were altered.

Experiment 1.—Dog, male, 11 kilos. Skillful etherization. Full anesthesia by open method. Equilibrating air 5.6 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content vol. per cent.	Blood CO_2 Capacity vol. per cent.
a. m.				
8.30	Normal	21	51	50
9.00	Ether			
9.30		47	43	50
10.00		48	43	45
10.30		26	46	46
11.00		30	51	48
11.30		17	47	47
12.00		19	44	47
12.30	Shallow respirations	29	56	48
p. m.				
1.00	Less ether	21	46	45
1.30		14	48	44
2.00		19	50	44
2.30		29	44	46
3.00		25	41	45
3.05	Experiment stopped. Dog in good condition.			

If the *level of CO_2 and alkali* is reduced below the critical value lying between 33 and 36 volumes per cent. of CO_2, a condition of general depression of all vital functions results. Above the critical level the process appears to be reversible, for if CO_2 is administered in the air breathed and the CO_2 content of the blood is thus raised the CO_2 capacity follows it upward, probably because of the passage of the alkali from the tissues back into the blood. On the other hand if the marked resistance to further depletion of CO_2 capacity which occurs at the critical level is broken down and the CO_2 capacity further reduced, the result is a condition of vital depression from which the subject does not spontaneously recover. This condition may be termed acapnial shock.

EXPERIMENTAL.

IN THE FIRST experiment are shown the effects (in the dog) of careful and skillful etherization by the open method. The initiation of anesthesia was rapid, the administration as nearly uniform as practicable by this method, and both excitement of respiration from too little ether and depression from too much were avoided. The CO_2 content was reduced in the course of the first hour from the normal of 50 down to 45. It underwent no considerable change during the succeeding 5 hours.

Experiment 2.—Dog, female, 8 kilos. Etherization, open method, excessive respiration. Equilibrating air 5.5 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content vol. per cent.	Blood CO_2 Capacity vol. per cent.
p. m.				
4.00		18	47	49
4.24	Ether started			
4.26		44		
4.28		68		
4.30		74		
4.33		90		
4.35			38	48
5.00		62		
5.10			39	44
5.30		34		
6.10			40	43
6.30		46		
7.10			38	41

In the second experiment the initiation of anesthesia was purposely made unskillfully slow. The dog was allowed to struggle in the stage of excitement for a considerabe time, and when this period came to an end the ether was given irregularly so that at no time was there deep anesthesia.

In the third experiment is afforded an example of extremely bad light etherization, yet which was not so bad as to cause early death from failure of breathing (apnea). The excessive breathing reduced the CO_2 content of the blood progressively and the CO_2 capacity followed downward with the usual lag until at a

CO_2 capacity of 28 the animal was moribund It died soon after.

Experiment 3.—Dog, male, 14 kilos. Prolonged ether excitement. Equilibrating air 5.4 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content	Blood CO_2 Capacity
			vol. per cent.	vol. per cent.
a. m.				
9.20	Normal	19	54	51
9.30	Ether started			
10.00		63	44	52
10.30		82	39	44
11.00		70	36	43
11.30		78	37	44
12.00		42	36	41
12.30		84	35	39
p. m.				
1.00		59	37	38
1.30		76	31	36
2.00		56	22	37
2.30		59	24	31
3.00		82	27	28
3.15	Moribund. Ether stopped.			
3.19	Stopped breathing.			
3.24	Heart stopped. Dog dead.			

In the fourth experiment the same procedure was followed until the CO_2 content had fallen at the end of 210 minutes to 35 volumes per cent. and the CO_2 capacity to 38. The administration of ether was then stopped, and in the course of the succeeding 90 minutes the CO_2 content rose again nearly to normal and thereby caused the CO_2 capacity to rise to 46, only a little below the normal level.

Experiment 4.—Dog, male, 10 kilos. Light and irregular ether for 210 minutes, with spontaneous recovery toward normal during following 90 minutes. Equilibrating air 5.7 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content	Blood CO_2 Capacity
			vol. per cent.	vol. per cent.
a. m.				
9.30		20	50	53
9.45	Ether started			
10.00		82		
10.15			42	50
10.30		68		
10.45			36	47
11.00		66		
11.15			37	44
11.30		69		
11.45			36	41
12.00		59		
12.15			40	38
12.30		60		
p. m.				
1.15			35	38
1.20	Ether stopped			
1.45			43	39
2.15			49	43
2.45			47	46
2.50	Animal in good condition.			

Evidently in the foregoing experiment the decrease of the CO_2 capacity (alkaline reserve) was spontaneously reversible from the low level reached.

The first part of Experiment 5 was similar to the preceding experiment. After the CO_2 capacity had been reduced to 39 in this case however, instead of discontinuing the ether the amount administered was increased to a maximum just short of causing respiratory failure. This condition was continued for 80 minutes. Under the depression of respiration thus caused, the alveolar CO_2 was of course increased. The CO_2 content of the blood rose to 67 and the CO_2 capacity was raised to 54; that is, slightly above normal. The animal died soon after, probably from an insufficiency of oxygen.

Experiment 5.—Dog, male, 12 kilos. Light and irregular etherization followed by very deep etherization (with no rebreathing). Equilibrating air 5.65 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content	Blood CO_2 Capacity
			vol. per cent.	vol. per cent.
p. m.				
3.00		21	49	50
3.15	Ether started			
3.45		82	39	47
4.15		73	37	42
4.45		57	38	43
5.15		61	36	40
5.45		63	39	39
6.00	Ether increased to limit			
6.15		47	43	39
6.45	Blood dark	37 shallow	53	41
7.15	Blood dark	46 shallow	67	54
7.23	Dog dead			

From this experiment it is clear that when the CO_2 content is lowered by etherization the effect is not due to any influence of the ether *per se* other than the excessive pulmonary ventilation and low alveolar CO_2. In order, however, to make absolutely sure of this point we performed Experiments 6 and 7 We reasoned that if ether acts in some obscure way upon metabolism to induce *acidosis* (the opinion now widely held),

Experiment 6.—Dog, male, 9 kilos. Profound etherization and depressed respiration. Equilibrating air 5.5 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content	Blood CO_2 Capacity
p. m.			*vol. per cent.*	*vol. per cent.*
3.30	Normal	16	52	50
3.45	Ether started pushed rapidly			
4.15		11	60	54
4.30	Shallow respirations. Blood dark	16	57	56
4.45	Shallow respirations. Blood dark	22	57	55
5.15	Shallow respirations. Blood dark	8	60	61
5.20	Breathing stopped. Dog dead.			

Experiment 7.—Dog, male, 7 kilos. Similar to Experiment 6. Equilibrating air 5.6 per cent. CO_2.

Time	Condition	Respirations per min.	Blood CO_2 Content	Blood CO_2 Capacity
p. m.			*vol. per cent.*	*vol. per cent.*
6.10	Normal	21	47	47
6.30	Ether started. Administered rapidly			
7.00	Respirations very shallow	*blood dark* 72	64	63
7.05	Ether lightened			
7.30	Shallow respirations	32	59	60
7.45	Shallow respirations	40	63	60
7.50	Dog in critical condition. Ether stopped.			
7.52	Three or four more breaths, then breathing stopped, heart beating.			
7.56	Heart stopped. Dog dead.			

then the more ether administered the greater should be the so-called acidosis and the lower the CO_2-combining power. As ether in low concentrations excites and in high concentrations depresses respiration, it was easy to frame a crucial experiment. Thus in Experiments 6 and 7 an etherization so profound was maintained that respiration was depressed and the CO_2 content rose instead of falling. As the protocols show the CO_2 capacity followed upward, rising from 50 to

Experiment 8.—Dog, male, 9 kilos. Light etherization with CO_2, inhalation. Tracheal cannula connected with closed circuit ether bottle. Air containing approximately 7 per cent. of CO_2 administered through ether. Dog at all times was kept under very light ether as determined by periods of struggling, vigorous breathing, and full reflexes. Equilibrating air 5.45 per cent. CO_2.

Time	Condition	CO_2 breathed	Blood CO_2 Content	Blood CO_2 Capacity	Arterial pressure
p. m.		*per cent.*	*vol. per cent.*	*vol. per cent.*	*mm.*
3.30	Normal	0	49	51	
4.00	Under ether	0	42	49	170
4.05	CO_2 started	7.5			
4.15		7.5	58	50	168
4.45		7.1			
5.00		3.8	52	55	150
5.30		7.7	63	57	150
6.15		7.6	55	55	154
6.45		7.0	60	57	160
7.15		6.8	56	56	150
7.45		6.8	53	54	160

Dog in excellent condition.

Experiment 9.—Dog, male, 14 kilos, young. Similar to Experiment 8. Equilibrating air 5.5 per cent. CO_2.

Time	Condition	CO_2 breathed	Blood CO_2 Capacity	Blood CO_2 Content	Arterial pressure
p. m.		*per cent.*	*vol. per cent.*	*vol. per cent.*	*mm.*
2.48	Normal	0	48	47	
3.15	Ether started				
3.42		0			128
3.45	CO_2 started	6.2			
4.45		6.2	63	56	116
5.45		6.0	68	54	110
6.45		7.7	71	51	114
7.45		6.4	62	56	110
8.45		7.1	67	55	108

Dog in good condition. Blood a good bright normal color.

61 in one case, and from 47 to 60 in the other.

Even Experiments 6 and 7, decisive as they appear in contrast to those preceding them, *e. g.*, Nos. 2, 3, 4, and 5, might leave open the possibility that the excitement of light ether causes a depression of the CO_2 capacity in some way (*e. g.*, excessive adrenal secretion) other than by the blowing off of CO_2. Accordingly we performed Experiments 8 and 9 in which light etherization was maintained for several hours but loss of CO_2 was prevented by the fact that the air which the animal breathed was enriched by the addition of CO_2 in the amounts shown in the protocols. It will be seen that in both cases the CO_2 capacity was slightly elevated and that when the experiments were discontinued, after 5½ and 4¼ hours respectively, the animals were in excellent condition.

CONCLUSIONS.

THE DISTURBANCE OF THE CO_2 capacity of the blood by ether appears from these experiments to be wholly dependent on disturbance of respiration. If the anesthesia is managed so that respiration is but little increased, the lowering of the CO_2 capacity of the blood is slight. Ether hyperpnea, however, causes a very great reduction. Down to the critical level between 33 and 36 volumes per cent. the process is spontaneously reversible and the animal recovers. Below this level it appears to be irreversible, and death ensues.

At present such effects even above the critical level are generally interpreted as acidosis. Our results show them to be of a very different origin. It is possible, however, that below the critical level a true acidosis of an asphyxial character sets in.

Etherization so profound as to depress respiration causes a rise of the CO_2 capacity.

Light etherization such as is otherwise most effective in lowering the CO_2 capacity, and most harmful to the subject, loses this influence when administered with sufficient CO_2 to maintain the alveolar CO_2 at a normal level.

From these facts it is clear that under ether the CO_2 capacity of the blood (alkaline reserve) follows and is controlled by the CO_2 content, and that the CO_2 content is in turn dependent upon the alveolar CO_2, which is determined by the breathing.

These results afford, we believe, final proof of the essential correctness of the views on this topic (acapnia under anesthesia[3]) which have been advocated now for 10 years past in papers from this laboratory.

We desire to acknowledge our debt to Van Slyke and his collaborators[4] for bringing forward the conception of the *alkaline reserve*, or as we prefer to call it the CO_2 capacity of the blood. This conception has enabled us to produce proof on a topic which after controversy and general rejection was evidently passing into oblivion.

3. Bryant, J., and Henderson, Y.: J. Am. Med. Assn., 1915, Vol. lxv, 1 (discussion of clinical aspects of problem and references to previous work).
4. Van Slyke, D. D., Stillman, E., and Cullen, G. E.: J. Biol. Chem., 1917, Vol. xxx, 401.

BLOOD CHANGES UNDER ANESTHESIA . CELL CHANGES UNDER NITROUS OXID-OXYGEN . EXPERIMENTAL METHODS . RED AND WHITE CELL COUNTS . H-ION CONCENTRATION . BLOOD CHANGES UNDER ETHERIZATION . CHANGES IN BLOOD VOLUME . EFFECTS ON BLOOD LIPOIDS, SPECIFIC GRAVITY, RED CELLS AND HEMOGLOBIN, LEUCOCYTES AND DIFFERENTIAL BLOOD COUNT . ETHERIZATION AND PHAGOCYTOSIS . SUMMARY . EFFECTS OF ANESTHESIA ON BLOOD VOLUME . METHOD OF ESTIMATION . CHANGES IN THE CELL COUNT AND HEMOGLOBIN . INFLUENCE OF ETHER AND CHLOROFORM ON YIELDING AND RESISTING ANIMALS . MECHANISM OF REDUCTION . CONCLUSIONS . EFFECTS ON THE CATALASE CONTENT OF BLOOD OF INCREASING AND OF DECREASING THE DEPTH OF ANESTHESIA . THE EFFECT ON CATALASE OF EXPOSING BLOOD IN VITRO TO ETHER VAPOR UNDER PRESSURE . SPLANCHNIC STIMULATION AND THE OUTPUT OF CATALASE FROM LIVER . INFLUENCE OF PROLONGING THE EXCITEMENT STAGE IN ETHER ANESTHESIA . CONCLUSIONS . REDUCTION OF CATALASE BY VARIOUS ANESTHETICS . INFLUENCE OF DIFFERENT ANESTHETICS AND SUMMARY .

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CONTINUED INTEREST HAS BEEN manifested in blood changes under anesthesia and several experimental researches have been made that are valuable enough to deserve recording. In a previous paper by Casto[1], it was reported that nitrous oxid-oxygen anesthesia in man gives rise to a decrease in the erythrocytes, while 30 or 40 minutes after anesthesia a tendency was noted for the count of erythrocytes to return to its preanesthetic normal value.

In a paper read before the Panama Pacific Dental Congress, Casto[2] described the hematological changes in rats under nitrous oxid-oxygen anesthesia. (These preliminary researches were published in the Year-Book for 1915-1916.) A further report on the latter research was made to the Academy of Stomatology of Philadelphia, December 19, 1916, and also to the Interstate Association of Anesthetist at the Toledo meeting, October 9-11, 1917, and is herewith presented.

These experimental animals were albino rats (*Mus Norvegicus, var. Alba*) obtained from the Wistar Institute, litters of from three to six animals of uniform size and weight being used.

The skin of these animals is so thin and their eyes so pink that any change approaching lividity or cyanosis could be readily noticed. Changes in the appearance of the eyes were always very apparent, even before any lividity could be seen in the veins of the ears or tail.

1. Casto: Dental Cosmos, Vol. lvii, 881, 1915.
2. Casto: Dental Items of Interest, Vol. xxxviii, 595, 1916.

From these families of five or six, two or three were taken as control animals, so that our tests for normals were made from animals of the same weight and feeding as the anesthetized ones.

METHOD OF EXPERIMENTAL PROCEDURE.

THE ANIMAL TO be anesthetized was placed on a table under a bell jar. The supply pipe for the gas was carried up through a hole in the table and allowed to enter 2½ inches above the top of the table. The exhaust tube was even with the table top, and had an elbow under the table so that the escaping gas might be collected for analysis. The whole appliance was sealed by pouring melted paraffin around the edge of the bell jar, an airtight apparatus being thus secured into which the gas was readily delivered. In this chamber the animal could be kept under constant observation, and anesthesia was readily controlled, while such outside influences as fright and shock could be avoided.

Nitrous oxid and oxygen were delivered into the jar by one of the modern appliances for measuring and regulating the flow of the gas. At first a large amount of oxygen was given, 25 parts oxygen to 75 parts nitrous oxid, which was gradually reduced to 5 parts oxygen and 95 parts nitrous oxid. (The chamber in which the animal was anesthetized being large as compared with the respiratory requirements of the animal, satisfactory anesthesia was not readily produced by immediately using the latter mixture.) All the animals were kept in a narcosed condition for at least 30 minutes. An examination of the clinical records of the animals anesthetized shows

TYPICAL PROTOCOL.
Rat 25. July 23, 1916.

Time	N_2O	O	Respirations	Comment
1.10	85	15		Operators left for lunch.
2.20			96	Partial paralysis of hind legs. Movement diffcult.
2.40	92	8	120	
2.50			135	Increased paralysis of hind legs.
3.10	95	5	115	Increased paralysis of legs.
3.15				Increased paralysis of legs.
3.27			120	Drags hind legs.
3.35	97	3		
3.36			100	Respiration a little labored. Good anesthesia.
3.37	80	10		Collapse.
3.38	90	10		Return to anesthesia.
3.40			108	
3.42	90	4		Return to consciousness.
3.43	100			
3.44			150	
3.45				Cyanosis of tail and hind legs.
3.53			116	
3.54	97	3	64	Labored breathing.
3.55			100	Collapse.
3.57	90	10		Complete anesthesia.
3.59			80	
4.02			80	Deep anesthesia.
4.06			116	
4.07	97	3		
4.12			112	Deep anesthesia.
4.14			60	Deep anesthesia.
4.16	100		170	Deep anesthesia.
4.17			17	Died.

Blood taken from tail.

	Before N_2O-O	After N_2O-O
Erythrocytes	6,392,000	5,456,000
Leucocytes	7,000	4,500
Polynuclear neutrophiles	5%	
Small lymphocytes..	49%	55%
(Macrocytes and microcytes present.)		p H, 7.25.

	Before N_2O-O	After N_2O-O
Large lymphocytes.	6%	6%
Transitional	36%	37%
Eosinophiles	4%	2%
2 segments	75%	
3 segments	25%	
R p H, 7.65.		

that after the first collapse many of them developed a certain amount of immunity to large doses of nitrous oxid. A careful record was made of the physical changes produced in each animal under anesthesia; respirations were counted every five minutes, cyanotic conditions being noted, and the movements of the body were observed throughout the period of narcosis. (See Typical Protocol.)

The hind leg became paralyzed first, and weakness in the back muscles was observed some time before anesthesia was produced. At this stage the animal would respond to any loud sound by pulling itself about with the fore feet, absolutely no motion being made with the hind feet. The paralysis was followed by deep anesthesia, with the respirations running from 50 to 72 per minute; below 50 the drop in number of respirations became very rapid. The animals were often restored after the respirations had dropped to 6 or 10 per minute by using a large supply of oxygen and resorting to artificial means such as compressing the abdomen and holding the animal up by the tail. After anesthesia had been continued from 35 minutes to one hour the animal was removed from the anesthetic chamber, killed by quick decapitation, and sufficient blood secured to make a study both of the change in erythrocytes and leucocytes and of the hydrogen ion concentration.

RED AND WHITE CELL COUNTS.

THE ERYTHROCYTES AND the leucocytes were counted by means of a Thoma-Zeiss pipet and counting chamber, and a differential study of the leucocytes was made using a double stain of methylene blue and eosin. The p H of the blood was determined by the method of Levy, Rowntree, and Marriott, and the R p H by the method of Marriott. The standard solutions of known hydrogen ion concentration were checked by means of the hydrogen electrode or gas chain.

Chisolm[3] made a count of the erythrocytes in 50 rats, getting an average of 8.8 millions per cubic millimeter.

Rivas[4] reports a series of ten counts of erythrocytes in normal rats. The number of erythrocytes varies from 7 4 millions to 9.2 millions per cubic millimeter. He also reports a differential

TABLE I.

	Erythrocytes.			Leucocytes.			
Experiment Number	Before N_2O-O	After N_2O-O	Percentage Decrease	Before N_2O-O	After N_2O-O	Percentage Decrease	Percentage Increase
20	7,020,000	5,856,000	16	4,150	5,000		20
22	7,316,000	6,056,000	17	9,500	8,500	10	
23	4,440,000	3,004,000	32	4,150	14,750		255
25	6,392,000	5,456,000	13	7,000	4,500	35	
26	6,988,000	3,600,000	48	5,000	3,000	40	
29	6,192,000	3,792,000	38	7,500	13,000		73
30	5,792,000	4,768,000	17	5,000	7,000		40
32	6,792,000	2,008,000	70	5,500	8,000		45
34	4,520,000	1,504,000	66	10,000	7,500	25	
35	2,480,000			3,000			
36	5,904,000	5,608,000	11	9,000	10,000		11
37	4,816,000	3,448,000	28	9,500	7,500	21	
38	6,400,000	3,832,000	40	18,000	20,000		11
41	6,288,000	6,048,000	3	5,500	6,000		9
44	4,296,000	2,568,000	40	4,000	19,500		137
45	4,648,000	3,848,000	17	4,000	3,000	25	
46	4,756,000	3,928,000	17	7,500	7,000	6	
51	5,840,000	4,632,000	20	20,000	18,500	7	
53	5,392,000	5,168,000	4	27,000	13,500	50	
55	5,152,000	5,096,000	1	19,000	12,000	36	
57	5,592,000	5,448,000	2	17,000	10,000	42	

Maximum 70
Minimum 1
Average 25

3. CHISOLM, R. O.: Quarterly Journal of Experimental Physiology, Vol. iv, 207-229, 1911.
4. RIVAS, (Quoted by Donaldson): "The Rat." Memoirs of the Wistar Institute, No. 6, 40-41, 1915.

count of the leucocytes in the same animals.

In the present study a much greater variation was found in the erythrocytes, there being a difference of 4.8 millions per cubic millimeter between the highest and lowest counts in the 21 animals studied. (See Table I.)

The erythrocytes were decreased in number after anesthetization with nitrous oxid and oxygen for thirty minutes to one hour, the maximum decrease in the 20 animals studied being 70 per cent., the minimum 1 per cent., with an average of 25 per cent. Macrocytes and microcytes were present in a few cases, but no poikilocytes or nucleated cells were observed. The ability of the erythrocytes to retain their stain was also found to be slightly lessened in a few of the animals.

The leucocytes did not show any change in actual number that was constant throughout the series of experiments, there being a decrease in number in 12 out of the 20 animals, and an increase in 8. (See Table II).

A study of the different varieties of leucocytes, however, showed a marked tendency on the part of the polynuclear neutrophiles to decrease and of the lymphocytes to increase. Of the 20 animals studied, 18 gave a decrease in polynuclear neutrophiles, varying from 1 to 75 per cent., and 16 of the 20 animals gave an increase in lymphocytes varying from 5 to 23 per cent.

TABLE II—PERCENTAGE OF LEUCOCYTES.

	Polynuclear Neutrophiles.				Lymphocytes.				Transitionals.				Eosinophiles.			
Exp. No.	Before N_2O-O	After N_2O-O	Percentage Decr.	Percentage Incr.	Before N_2O-O	After N_2O-O	Percentage Decr.	Percentage Incr.	Before N_2O-O	After N_2O-O	Percentage Decr.	Percentage Incr.	Before N_2O-O	After N_2O-O	Percentage Decr.	Percentage Incr.
20	36.5	34	6		15.4	48		5	11	13		.18	7	5	25	
22	26	21	19		68	72		5	6	24		300				
23	17.1	5	75		61.4	74		20	14	11	21		7	10		42
25	5				55											
26	34	33	2		46	54.5		18	14	9.5	80		6	3		50
30	26	25.7	1		41	56.5		37	23	12	50		10	5.7	43	
32	49	23	53		33	60		81								
34	35	9	74		51	59		15	14	25		54	0	7		
36	48	47	2		41	41			7	8		14	4	3.5		
37	43.5	31	34		41	40	2		8.5	12		41	7	7		
41	50	20	60		41	82		100	9	11		22				
45	22	3	90		69	91		31	7	6	14		2	0	2	
46	37	30	19		50.5	63		24	11	3.5	68		1.4	3.5		150
51	31	31			62	54	12		7	9		20	0	6		
53	52	18	55		39	65		66	5	15		200	4	2	50	
55	36	50		39	57	35	38		9	13		44	1	2		100
57	27	43		58	63	48	21		8	7	12		2	2		

A study of the transitionals and eosinophiles showed that there was no change of special interest, the decrease and increase being about equal throughout.

A study of the segmentation of the polynuclear neutrophiles also revealed little of interest, no constant change in either direction being observed. (See Table III.)

HYDROGEN ION CONCENTRATION OF THE BLOOD.

THE CARBON DIOXID—carbonic acid—content of the alveolar air and of the blood in a sense controls respiration, since carbon dioxid stimulates the respiratory center. According to Haldane,[5] under normal conditions the carbon dioxid content of the alveolar air has an almost constant value of 5.6 per cent. *Carbon dioxid forms by far the greatest portion of the products of metabolism which are acid in nature.* Formed in the tissues, it is absorbed by the blood plasma and carried to the alveoli of the lungs; here it is largely replaced by oxygen in the gas exchange, and the blood, as it leaves the lungs, normally contains in solution air which has a carbon dioxid content of 5.6 per cent. If the carbon dioxid content of the circulating blood and of the alveolar air becomes abnormally high, the respiratory center is subjected to an added stimulation and causes a deeper and more fre-

5. HALDANE: Science (New Series), Vol. xliv, 624, 1916.

TABLE III—PERCENTAGE OF POLYNUCLEAR NEUTROPHILES.

	With 1 Segment.				2 Segments con.				2 Segments.				3 Segments.				4 Segments.			
			Percentage				Percentage				Percentage				Percentage				Percentage	
Exp. No.	Before N_2O-O	After N_2O-O	Decr.	Incr.	Before N_2O-O	After N_2O-O	Decr.	Incr.	Before N_2O-O	After N_2O-O	Decr.	Incr.	Before N_2O-O	After N_2O-O	Decr.	Incr.	Before N_2O-O	After N_2O-O	Decr.	Incr.
20	16.4	6	60		4	11		175	68	61.2	1		11.4	20.4		7		1.4		
22	21	4	80		23	24		4	52.5	56		6	3.5	16		71				
23	14	0			5	0			62	50	79		14	50		27	5	0		
25	0	0			0	0			75	0			25	0			0	0		
26	2.5	8		220	31	14	54		49.2	60		21	16	16			1.2	2		66
30	4	3	25		7.2	0			70.2	91		3	14.4	6	5		4	0		
32	3.6	2	4		8	6	25		58.6	63		7	28.8	27	6		1	2		100
34	0	0			3	12.5		316	45.5	62.5		3	48.5	19	6		3	6		100
36	4	3.2	2		17	8.5	5		57	64		12	21	22.3		6	1	2		100
37	4	2.1	4		4	5.3		3	62	48	22		29	38.2		31	1	3.2		22
41	2	16		7	3	0			73	64	12		22	20	19					
45	11	20		81	8	0			70	81		15	11	0			0	0		
46	4	6		50	5	4.5	1		74	67	9		17	19.4		14	0	3		
51	15.5	9	42		64.4	6.5	90		4.4	62		131	15.5	19.5		3	0	3		
53	2.6	3		15	8.7	3	65		66	83		25	22.7	11	51		0	0		
55	0	0			0	0			68.4	63	7		31.4	36		14	0	1		
57	4	4.3		75	2	5.3		165	72	73.4		19	22	17	22					

quent respiration. As a result of this ventilation the excess of carbon dioxid is expelled through the lung, and the normal relations between acids and bases are restored in the blood. The hydrogen ion concentration or degrees of alkalinity of the blood is thereby kept approximately constant.

If, through disease or medication, acids which are not excreted through the lungs are formed and enter the blood stream, more rapid and deeper breathing may compensate their presence and maintain the normal alkalinity of the blood. Should the quantity of these non-volatile acids be such that increased respiration does not maintain the normal alkalinity of the blood, the condition known as acidosis exists, and the blood becomes neutral or even acid in reaction.

In physical chemistry the reaction of a solution is expressed by its hydrogen ion concentration. This term requires an explanation. Study of solutions has shown that when a compound belonging to the group of electrolytes—which in-

TABLE IV.

Normal Rats.

Exp. No.	pH	RpH
21	7.4	7.65
24	7.34	7.9
27	7.3	7.9
31	7.15	7.7
33	7.45	8.4
39	7.5	8.5
40	7.5	7.9
42	6.6	7.9
43	6.6	7.2
47	7.5	8.4
52	7.4	7.9
54	7.3	7.6
56	7.6	8.4
58	7.6	8.4
59	6.6	7.3
Maximum	7.6	8.5
Minimum	6.6	7.2
Average	7.25	7.95

Rats Anesthetized with N_2O-O.

Exp. No.	pH	RpH
20	7.3	7.5
22	7.3	7.4
23	7.0	7.2
25	7.25	7.65
26	7.3	8.0
28	7.25	7.7
30	7.0	7.3
32	7.4	8.6
34	7.1	7.4
35	6.8	7.1
36	7.0	7.5
37	7.25	7.8
41	7.4	8.0
44	6.6	6.6
45	7.3	7.8
46	6.6	7.7
53	7.5	7.8
55	7.0	7.6
57	7.1	7.6
Maximum	7.5	8.6
Minimum	6.6	6.6
Average	7.1	7.6

cludes practically all acids, bases, and salts—is dissolved in pure water, the compound undergoes electrolytic dissociation into a positively charged ion and a negatively charged ion; the solution acquires the power to conduct the electric current, and the positively charged ions and negatively charged ions travel with the current to the negative pole and the positive pole respectively. Thus hydrochloric acid yields the positively charged hydrogen ion H^+, and the negatively charged chlorid ion Cl^- In fact all acids yield the H^+ ion. On the other hand, all bases yield the negatively charged hydroxyl ion $(OH)^-$.

When hydrogen ions predominate in a solution, it is acid in reaction; when hydroxyl ions predominate, it is alkaline in reaction. When

Figs. 1, 2, 3. Photomicrographs from sections of the spleens of *normal* rats. Figs. 1 and 2 from 2/3 and Fig. 3 from 1/6 Objective.

the hydrogen and hydroxyl ions are present in equal quantities, the solution is neutral in reaction; this condition exists in pure neutral water which is slightly dissociated into hydrogen ions and hydroxyl ions. One liter of water at a temperature of 20° C. contains 0.0000001 (one ten-millionth) gram of hydrogen ions; using the nomenclature of standard solutions, and volumetric analysis, this represents a hydrogen ion concentration of 0.0000001 normal, which may also be written 10^{-7} normal, or, as suggested by Sorensen,[6] p H 7

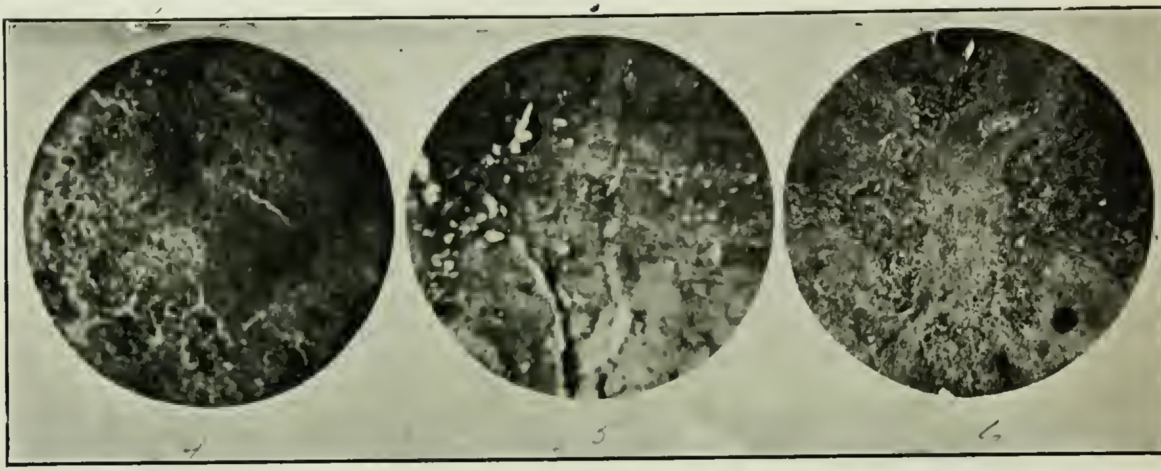
Since the number in the term p H is the negative exponent in the logarithmic statement of the hydrogen ion concentration, when the number is less than 7, the solution is acid; when it is greater than 7, the solution is alkaline. Thus the hydrogen ion concentration is p H 6 in a solution which has an *acidity* 0.000001 normal, and is p H8 in a solution which has an *alkalinity* 0.000001 normal.

METHODS OF DETERMINING HYDROGEN ION CONCENTRATION.

THE TWO COMMONER methods for the determination of the hydrogen ion concentration of a solution are the electrometric method, using a gas chain or hydrogen electrode, and the indicator method. In the indicator method a suitable indicator is added to the solution of unknown hydrogen ion concentration, and to a series of standard solutions of which the hydrogen ion concentration is known, having been ascertained by the electrometric method. By matching the color of the unknown solution against the known solutions, the hydrogen ion concentration of the unknown solution is readily determined. The chief obstacle to the application of this method to blood has been the color of the

6. SORENSEN: Ergebnisse der Physiologie, Vol. xii, 393, 1912.

blood itself. This obstacle has been overcome in a method recently devised by Levy, Rowntree, and Marriott,[7] who dialyzed the blood contained in a celloidin sack against physiological salt solution, and determined the hydrogen ion concentration in the dialysate, which is free from proteins and blood pigments, by the colorimetric method, using phenolsulphonephthalein as the indicator; this compound "exhibits definite variations in quality of color with very minute differences in hydrogen ion concentration between p H 6.4 and 8.4." For standards of known hydrogen-ion concentration they use a series of solutions; each contains mono-potassium phosphate and di-sodium phosphate mixed in definite proportions. Their procedure renders it possible to determine the figure in the p H to a tenth, and at times, by interpolation, to a twentieth (0.05) of a unit.



Figs. 4, 5, 6. (4) Rat 20 under gas for 88 minutes. Sections of spleen seem to be normal in every way; $\frac{2}{3}$ Objective. (5) Rat 22, under gas 70 minutes, the section of spleen showing no deviation from normal. (6) Rat 23, under gas for 126 minutes. Tissues normal.

Figs. 7, 8, 9. (7) Rat 23. Malpighian corpuscles more diffuse in character; $\frac{2}{3}$ Objective. (8) Rat 28 under the bell jar for 90 minutes. There is a decrease in the number of Malpighian corpuscles, probably also a diminution in the number of lymphocytes. This may, however, be a normal condition and not due to the narcosis; $\frac{2}{3}$ Objective. (9) Rat 35, under gas for 34 minutes. This section shows an increase in the number of Malpighian corpuscles, but there is no evidence that this is due to the anesthesia; $\frac{2}{3}$ Objective.

7. Levy, Rowntree and Marriott: Archives of Internal Medicine, Vol. xvi, 389, 1915.

Marriott[8] has modified this method, so that, in addition to the hydrogen ion concentration of the blood, the alkali reserve of that fluid is also determined. The procedure is quite simple. After p H has been determined in the usual manner, a current of air is forced through the dialysate from the blood for a period of three minutes in order to expel the absorbed carbon dioxid; the dialysate is then compared with the standards of known hydrogen ion concentration for a second time in order to determine its hydrogen ion concentration. This residual hydrogen ion concentration is termed R p H; the difference between R p H and p H represents the alkali reserve of the blood, and also is a measure of the carbon dioxid content of that fluid. As the alkali reserve of the blood diminishes and the condition of acidosis is approached, the numerical value of R p H becomes lower than normal.

While both p H and R p H showed wide variations between their maximum and minimum values in both the normal and the anesthetized rats, careful scrutiny of the apparatus, the reagents, and the technic failed to reveal any reason for rejecting any of the results. Since the average value of p H is slightly less in the anesthetized rats than in the normal animals, the hydrogen ion concentration was slightly greater in anesthesia than under normal conditions. As to R p H, it was numerically greater than 7—neutrality—in two-thirds of the normal rats, and in but one-third of the anesthetized rats, showing that the alkali reserve of the blood was depleted during anesthesia. This decrease in the alkali reserve was comparable to that of a mild acidosis in man. (See Table IV.)

The average R p H was 7.95 in normal rats and 7.60 in anesthetized rats, a difference of 0.35. Marriott's figures for R p H in man are—Normal adults 8.4 to 8.55, moderate degree of acidosis 8.0 to 8.3; the difference here would be between 0.1 and 0.55.

There is no doubt that the animals in these experiments which show a pH of 6.6 or anything below pH 7 should be eliminated as no animal could live with this amount of acidosis. This reading can be explained by the method of obtaining the blood. This was as follows: the animal was decapitated and the blood drained into the cup and no doubt but that some part of the stomach contents were collected in some experiments in normal and anesthetized rats. If these are not counted an average of 7.42 pH and 8.05 RpH is obtained for twelve normal rats, and an average of pH 7.21 and 7.68 RpH for the sixteen anesthetized rats.

8. Marriott: Archives of Internal Medicine, Vol. xvii, 840, 1916.

HISTOLOGICAL EXAMINATIONS OF SPLEENS.

TO DETERMINE THE ROLE of the spleen in the blood changes under anesthesia sections were properly prepared and stained with hematoxylene and photomicrographs made. Expressed in general terms it may be said that no evidence was developed from the sections examined showing any profound or even slight pathological conditions existing.

We must conclude, as far as these studies have been made, that there are no radical changes which take place in the tissue of the spleenic pulps, the cells nor in the Malpighian corpuscles of the spleens of those rats which were given a continuous dose of nitrous oxid-oxygen until death supervened.

In closing we wish to express our appreciation of the co-operation extended in these studies by E. I. St. John, M. D., and A. Hopewell Smith, N. R. C. S., L. R. C. P., D. D. S.

F. C. MANN, working in the Laboratory of experimental Surgery of the Mayo Clinic has investigated some bodily changes under ether with special reference to the blood. He reported his results to the American Association of Anesthetists during its Fourth Annual Meeting, in

Detroit, Michigan, 1916, and these were published in the Anesthesia Supplement of the American Journal of Surgery, October, 1916. His researches are so interesting and valuable that they are, herewith, presented in detail.

ASSOCIATED CONDITIONS.

IN STUDYING THE bodily changes due to an anesthetic or occurring during the anesthetized state, it is necessary to differentiate carefully the effect of associated conditions. The preliminary excitement, struggling, asphyxia and other accompanying phenomena produce changes quite apart from the anesthetic itself. The compensating physiologic mechanism necessary in light anesthesia is probably not the same as when a deep anesthetized state is produced. A short or long period of anesthesia may differ only in degree, provided the anesthetic tension remains the same.

The present investigation deals mainly with a study of the blood of dogs under ether anesthesia. While some of the associated conditions were also included in the study, in general only the results obtained while the animal was under surgical anesthesia will be emphasized.

The blood is the carrier of the anesthetic substance in every method of general anesthesia, and it is important to know definitely how it is affected by each anesthetic either directly or indirectly. This knowledge is of especial value in view of the fact that today more patients than ever before are being operated on under general anesthesia who have a lower hemoglobin content and more pathologic changes of other kinds.

METHODS OF ETHERIZATION.

WHILE IN THE experiments herein reported the methods of etherizing differed, depending on the condition desired, the general procedure consisted in a preliminary etherization in a closed cabinet until the animal was completely relaxed, followed by the employment of the auto-inhalation method.[1] The latter consists in intubating in the same manner as for intratracheal insufflation. The intubation tube is connected through a valve tube with a double perforated ether can, which allows of a limited amount of rebreathing. With little effort, constant anesthesia can be maintained in this manner for long periods.

CHANGES IN BLOOD VOLUME.

IT WAS IMPORTANT to determine first whether the amount of circulating blood was diminished. This was estimated according to a method described in a previous publication,[2] which consisted in bleeding the animal from the femoral artery and from the right heart and then comparing the amount of blood obtained with the total amount present in the body, estimated on the basis of 77 per cent. of the body weight[2] While this method gives only comparative results, it is accurate enough, when carefully controlled, to show gross changes. In a series of six normal animals which were bled immediately after being etherized, I was able to obtain an average of 76 per cent. of the estimated amount of blood. In a series of six animals which were bled after from six to nine hours of light etherization, only 64 per cent. of the estimated amount of blood was obtained. The decrease in the amount of circulatory fluid would probably have been much greater if deep anesthesia had been employed. The result is due undoubtedly to loss of muscle tone and venous stagnation, as explained by Gatch.[3] (See Circulatory Disturbances: Year-Book, 1915-1916.)

EFFECTS ON BLOOD LIPOIDS.

THE LIPOIDS OF the tissues seem to have the greatest affinity for the most common anesthetic substance. Of these lipoids, lecithin and cholesterin are the most important. The dissolving power of ether and chloroform for

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1. McGrath, B. F.: Anesthesia in Surgical Research. Surgery, Gynecology & Obstetrics, 1914, Vol. xviii, 765.

2. Mann, F. C.: Shock and Hemorrhage, an Experimental Study. Surgery, Gynecology & Obstetrics, 1915, Vol. xxi, 430.

3. Gatch, W. D.: The Effect of Laparotomy Upon the Circulation. Trans. American Gynecological Society, 1914, Vol. xxxix, 180; American Journal of Obstetrics, 1914, Vol. lxx, 55; American Year-Book of Anesthesia & Analgesia, 1915-1916.

these two lipoids has formed the basis for the best known theory of anesthesia. As it has been shown that lecithin is greatly increased in the blood during anesthesia,[4] it was desirable to know whether the cholesterin content of the blood also underwent changes. Accordingly, determinations of the cholesterin value of the blood were made in one series of experiments. The method employed was that described by Bloor.[5] The cholesterin was estimated just before anesthesia, immediately after a stage of prolonged excitement and then at different intervals after etherization. In active dogs the cholesterin content of the blood does not seem to undergo any great changes during a period of time equal to that for which our dogs were kept under anesthesia. In the anesthetized dogs it was found to change considerably, but the variations were not uniform enough to permit definite conclusions. *In general, it seems that the cholesterin value increases during excitement, decreases below normal after an hour or so of anesthesia, and then gradually increases above normal on further etherization* (Experiment 62).

EFFECTS ON VISCOSITY AND SPECIFIC GRAVITY OF BLOOD.

PREVIOUS INVESTIGATION HAS shown that the viscosity and specific gravity of the blood remain the same under light anesthesia, but both increase when the animal is deeply anesthetized.[6] In several of these experiments the specific gravity was estimated by both the Hamerschlag and the Roy Jones methods, and the foregoing results were corroborated. *Under light ether anesthesia the specific gravity of the blood does not change even though the etherization is maintained for as long a period as ten hours. However, when the animal is deeply etherized and respiration becomes shallow, the specific gravity increases a few points in the fourth decimal, probably because of the asphyxia.*

EFFECT ON RED CELLS AND HEMOGLOBIN.

AS ETHER AND chloroform lake the blood, it has been thought that these anesthetics might have a deleterious effect on the red cells and hemoglobin. This possibility was tested in several experiments. A blood count and hemoglobin estimation were made before anesthesia and at different intervals after etherization. The ordinary hemocytometer and a Dare hemoglobinometer were used. *As a rule, neither the hemoglobin nor the number of red cells underwent changes greater than the coefficient of error, even after ten hours' etherization. In some of the*

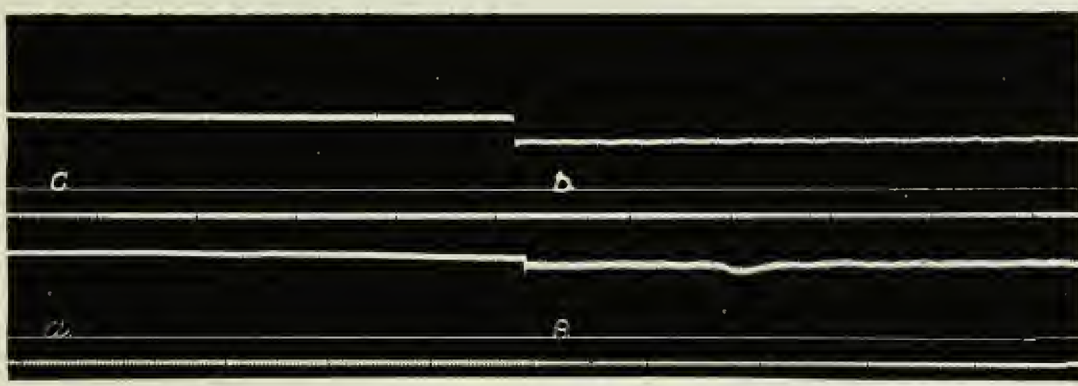

Fig. 1. Tracing showing changes in blood pressure under ether. *A* is the record of blood-pressure immediately after etherization; *B* in three hours; *C* in six hours and *D* in nine hours after etherization. During this time the pressure decreased from 105 to 60.

4. Reicher, quoted by Hewitt, F. C.: "Anesthetics." London, The MacMillan Company, 1912, 82.
5. Bloor, W. R.: Studies on Blood Fat; Fat Absorption and the Blood Lipoids. Journal of Biological Chemistry, 1915, Vol. xxiii, 317.
6. Burton-Opitz, R.: The Changes in the Viscosity of the Blood During Narcosis. Journal of Physiology, 1905, Vol. xxii, 385.

experiments there was an increase in both, but it was slight. In a few experiments the resistance of the red cells before and after etherization was determined by the fragility test of Ribierre.[7] No change in the resistance of the erythrocytes or hyposmotic salt solution was noted.

EFFECTS ON LEUKOCYTES.

LEUKOCYTOSIS OCCURS IN a dog under ether anesthesia, provided the anesthetic is maintained long enough. Occasionally the white cells increase in number within the first hour of anesthesia, but frequently not until after four hours. The increase may be very slight, in some animals not above the coefficient of error, but usually by the end of the fourth hour of anesthesia the number of white cells has doubled. The leukocytosis is not always progressive. Frequently a maximum number is reached which more prolonged etherization does not change. Sometimes there has been a decrease before the end of anesthesia. Usually, however, the number of white cells does not begin to decrease for a few hours after the animal has recovered from the anesthetic, and is still above normal twenty-four hours after etherization (Table I).

The leukocytosis just described is practically a constant and general phenomenon. It is not limited to the peripheral circulation, for the white counts are usually the same in the blood from ear veins, femoral veins and mesenteric veins (Experiments 54 and 80). This fact, that the white cells are increased in the blood in widely separated parts of the body, also eliminated the possibility that stagnation to dependent parts or reaction to external irritation were factors. Such leukocytosis occurs in animals in which a moderate leukocytosis is present already (Experiment 91). It resembles a leukocytosis of digestion. All of our experiments, however, were performed on dogs that had not had food from twelve to twenty-four hours. It differs from the leukocytosis produced by drugs, such as pilocarpin, in the fact that it is not a lymphocytosis and atropin does not prevent its occurrence (Experiment 77).

The spleen is not an important factor in its production, for it occurs also in animals that have been splenectomized. Its cause and site of action have not been definitely determined, but it would appear that it is a direct stimulation of the bone marrow.

TABLE 1.—CHANGES IN THE NUMBER OF WHITE BLOOD CELLS UNDER ETHER AT DIFFERENT HOURS AFTER ANESTHESIA.

No. of Exp.	Normal Count	First Half Hour	First Hour	Second Hour	Third Hour	Fourth Hour	Fifth Hour	Sixth Hour	Seventh Hour	Eighth Hour	Ninth Hour
51	......	18,400	......	......	19,100	......	......	27,200	......	......	39,300
52	......	10,920	......	......	14,470	......	......	14,520	......	......	15,400
53	......	15,960	......	......	13,420	......	......	18,340	......	......	18,870
54	......	13,200	......	......	14,400	......	......	29,900	......	......	29,900
60	7,000	......	8,100	......	......	......	15,000	15,800	......	......	......
61	10,400	18,400	......	20,250	......	......	39,900	......	......	......	......
69	12,150	13,700	......	......	......	......	24,000	......	......	19,000	......
70	21,450	25,000	......	......	......	......	......	32,750	......	......	......
71	20,600	......	......	......	......	23,450	......	......	......	......	......
72	33,850	44,550	......	......	......	......	......	......	50,450	......	......
73	19,800	......	......	......	......	......	39,400	......	46,100	......	......
74	13,300	13,950	......	......	......	36,400	......	......	51,300	......	......
75a	20,000	24,800	......	30,750	35,000	......	......	28,330	......	......	......
75b	8,000	......	10,000	14,000	17,000	23,830	25,230	25,000	27,000	29,000	......
76	14,900	18,700	20,000	26,900	27,900	67,920	29,300	30,000	......	......	......
77	18,050	......	18,450	20,000	24,800	28,650	30,500	......	35,800	......	......
78	21,450	......	33,650	35,400	44,100	45,000	45,000	......	......	40,000	......
79	14,000	......	17,750	21,650	23,850	25,000	21,180	23,050	......	......	......
81	12,000	18,000	19,250	18,000	21,650	23,300	......	24,580	......	......	......
82	26,000	......	......	......	35,000	......	......	39,000	......	......	......
83	25,000	......	......	......	30,000	......	......	......	......	......	......
85	18,500	......	......	......	20,100	......	......	......	......	27,100	......
86	12,000	......	......	......	......	......	19,452	......	......	......	......
87	17,000	......	......	......	......	......	19,000	......	......	......	......
88	16,100	......	......	......	......	......	25,400	......	......	......	......
89	15,100	......	......	......	30,500	......	......	47,450	......	......	......
90	11,800	......	......	......	......	......	19,000	......	......	......	......
91	21,000	......	......	......	......	......	......	40,100	......	......	......

7. RIBIERRE, P.: L'hémolyse et la mesure de la résistance globulaire; application à l'étude de la résistance globulaire dans l'ictère; Thèse de Paris, 1903; quoted by SAHLI, H.: "Diagnostic Methods," Philadelphia, W. B. Saunders, 1911, 769.

DIFFERENTIAL BLOOD COUNT.

DIFFERENTIAL COUNTS OF the blood before and after ether show that there may be an actual increase in all of the forms of white cells, but that the polymorphonuclear cells are usually the only form showing also a relative decrease of polymorphonuclear cells noted. The large lymphocytes usually decrease relatively, while the small lymphocytes always decrease. The transitional cells usually show an increase. In one experiment the eosinophils increased greatly. The size and character of all the cells remain normal (Table II).

TABLE II.—CHANGES OCCURRING IN THE DIFFERENTIAL BLOOD COUNT BEFORE AND AFTER LONG PERIODS OF ANESTHESIA.

Cells	Experiment 75		Experiment 76		Experiment 77		Experiment 79		Experiment 81		Experiment 89	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Polymorphonuclears	64	86	76	81	78	89	66	86	79	90	76	93
Large lymphocytes	13	5	9	6	6	3	6	6	6	5	10	3
Small lymphocytes	17	2	10	7	7	2	20	2	7	0	5	1
Transitionals	3	6	5	6	6	5	1	3	2	3	4	2
Eosinophils	3	1	0	0	3	1	7	3	6	2	5	1

ETHERIZATION AND PHAGOCYTOSIS.

STUDIES ON PHAGOCYTOSIS have demonstrated that the phagocyte reacts to anesthetics in a manner similar to other unicellular organisms. *Fat-dissolving substances, such as ether and chloroform, in weak solutions, stimulate phagocytic activity until a certain optimum strength of solution is reached. Any increase in the amount of anesthetic substance above this produces a decrease in phagocytosis and finally a paralysis of the cells.*[8]

In previous studies, the white cells have usually been subjected to artificial environment. They were separated from the blood, suspended in salt solution and, after the addition of the substance with which they were to be tested, such as carbon particles, were incubated for definite periods of time.

It was deemed of value to determine whether phagocytic activity was altered when the cells were subjected to concentration of the ether such as occurs in the blood under surgical anesthesia. In order to make conditions as nearly normal as possible, the following method was employed: Under local anesthesia one of the jugular veins was exposed, dissected entirely free from surrounding fascia and doubly ligated, a section about 10 cm. long being left between ligatures partially distended with blood. A suspension of *Bacillus coli* in salt solution was injected into this natural incubation tube, and after it was thoroughly mixed by rolling gently between the fingers, the skin was closed over the vessel. Under these conditions the blood does not coagulate, the phagocyte remains in its normal medium at approximately its normal temperature, and has access to the bacteria in approximately the natural way. After various intervals of time, an hour being found the most suitable, smears were made. These slides were used as controls. After definite intervals of etherization, the process was repeated on the other jugular vein with exactly the same technic.

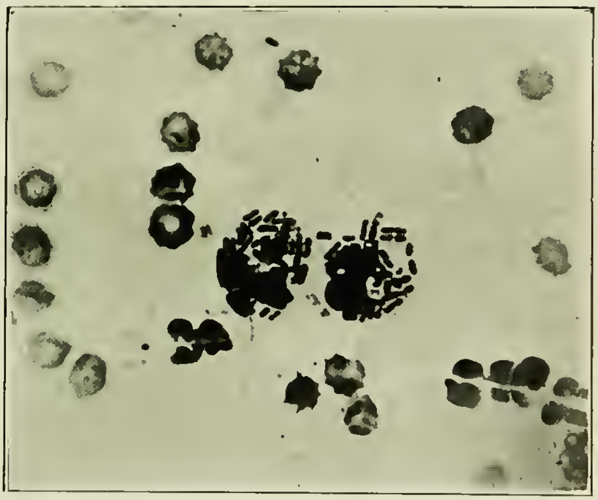

Fig. 2. Photomicrograph showing two phagocytes filled with bacteria. These cells had been subjected to five and a half hours of etherization before given access to the bacteria.

8. Hamburger, H. J.: Researches on Phagocytosis. British Medical Journal, 1916, Vol. i, 37.

The cells in the latter vein had been subjected for several hours to a concentration of ether strong enough to maintain the animal under surgical anesthesia.

The blood smears were stained, and a count of the phagocytes containing bacteria and the phagocytes without bacteria was made. Usually 200 white cells were counted on a slide, and frequently counts were made on several slides from one vein. The average was taken as the final result. Only the polymorphonuclear cells were included in this count. The occasional large lymphocyte or eosinophil containing bacteria was ignored. It is obvious that there are chances for error in the method, but I do not believe the average error exceeds 10 per cent.

TABLE III.—PHAGOCYTOSIS BEFORE AND AFTER ETHERIZATION.

Experiment Number	Normal Count W. B. C.	Count of W. B. C. at Time Bacteria Were Injected after Etherization	Percentage of Cells of Normal Blood Containing Bacteria	Percentage of Cells of Etherized Blood Containing Bacteria	Number of Hours Etherized
87	17,000	19,000	73.5	87	5
88	16,100	25,400	21	36.5	5
89	15,100	47,450	45.5	57.5	5½
90	11,800	19,000	50	50	5
91	21,000	40,100	90	90	6

The results show that phagocytes which have been subjected for from four to six hours to a concentration of ether which is capable of maintaining a dog under surgical anesthesia do not exhibit any marked changes in activity. In most of these experiments the greater number of cells containing bacteria was found in the blood subjected to the ether, but the increase was not sufficient to be of positive significance. It can be definitely stated, however, that there was no decrease in the phagocytic power of the cells in the blood subjected to etherization (Table III and illustration).

TYPICAL PROTOCOLS.

THE FOLLOWING EXPERIMENTS are presented as typical of the series they represent:

EXPERIMENT 54.—July 27, 1915, a young adult female terrier, weighing 5 kg., at 7:55 a. m. was etherized and blood data were taken immediately. The apparatus was arranged to record the carotid blood pressure.

EXPERIMENT 62.—Feb. 19, 1916, female bull terrier in excellent health; weight 17.6 kg.

8:20 a. M.: Blood withdrawn from left jugular vein for cholesterin estimation. Animal very quiet. Cholesterin value, 0.266.

8:21 a. m.: Animal placed in etherizing cabinet and etherized very slowly.

8:50 a. m.: Animal intubated.

8:52 a. m.: Blood withdrawn; cholesterin value, 0.312.

Animal kept under surgical anesthesia.

9:55 a. m.: Blood withdrawn. Cholesterin value, 0.180.

Animal maintained under anesthesia until 3 p. m., when, after another test was taken, it was allowed to recover.

3:00 p. m.: Blood withdrawn, cholesterin value, 0.358.

EXPERIMENT 77.—April 1, 1916, male mongrel; animal very quiet; weight 15.1 kg.

8:00 a. m.: Animal was given 1/9 grain morphin and 1/100 grain atropin subcutaneously.

8:30 a. m.: Count of white blood cells was taken.

8:45.: Etherized quickly by Cone method. Animal maintained under surgical anesthesia until 4 p. m., when it was allowed to recover.

The counts of white blood cells were as follows:

8:30 a. m., 18,050
10:00 a. m., 18,450
11:00 a. m., 20,000
12:00 m., 24,800
1:00 p. m., 28,650
2:00 p. m., 30,500
4:00 p. m., 35,800

EXPERIMENT 89.—May 3, 1916, adult mongrel, male; weight 9 kg.

8:15 a. m.: Count of white blood cells taken from right ear vein and smears for differential count. Right jugular vein exposed under local anesthesia. Doubly ligated vein leaving it almost filled with blood. Length of vein, 8 cm. Total white cells, 15,100. Differential count: polymorphonuclears, 76;

TABLE IV.—FINDINGS IN EXPERIMENT 54.

	Red Blood Cells	White Blood Cells	Specific Gravity	Hemoglobin	Blood Pressure
Blood taken from peripheral veins:					
Immediately after etherization	5,775,000	13,000	41	70	105
Three hours after etherization	5,437,000	14,400	41	..	80
Six hours after etherization	5,675,000	29,900	41	..	75
Nine hours after etherization	6,020,000	29,900	42	71	60
Blood taken from portal circulation:					
Nine hours after etherization	6,050,000	25,700	42	72	..

large lymphocytes, 10; small lymphocytes, 5; transitionals, 4; eosinophils, 5.

8.30 a. m.: Injected 1 cc. suspension of *Bacillus coli* into vein. Vein markedly distended. Gently mixed by compression.

9:00 a. m.: Animal etherized.

9.30 a. m.: Smears taken from right jugular vein showed that 45.5 per cent. of the phagocytes contained bacteria and 54.5 per cent. did not contain bacteria.

11:30 a. m.: Took count of white blood cells from right ear vein; count 30,500.

2:25 p. m.: Took count of white blood cells and smears for differential count from abdominal vein. Total count of white cells from abdominal vein, 47,430. Differential count: polymorphonuclears, 93; large lymphocytes, 3; small lymphocytes, 1; transitionals, 2; eosinophils, 1.

2:30 p. m.: Exposed and ligated left jugular vein. Injected 1 cc. of same suspension of *Bacillus coli*. Technic same as used on right vein.

3:00 p. m.: Count of white blood cells from mesenteric vein, 46,650.

3:30 p. m.: Smears made from blood of left jugular vein showed that 57.5 per cent. of the phagocytes contained bacteria and 42.5 per cent. did not.

Experiment 91.—May 11, 1916, young male, mongrel; had had distemper for about four days; weight 8.5 kg.

8:20 a. m.: Exposed left jugular vein.

8:44 a. m.: White blood cells, 21,000.

8:45 a. m.: Injected suspension *Bacillus coli* into ligated vein.

9:00 a. m.: Animal under ether.

9:45 a. m.: Made smears from left vein. Of the phagocytes 90 per cent. contained bacteria.

Animal maintained under surgical anesthesia.

3:00 p. m.: Exposed right jugular vein and injected bacteria.

3:02 p. m.: Count of white blood cells, 40,100.

4:00 p. m.: Made smears from right vein. Ninety per cent. of the phagocytes contained bacteria.

SUMMARY.

A STUDY OF the blood of dogs subjected to etherization demonstrated the following facts: The amount of circulatory blood is diminished about 10 per cent. after six to nine hours of light etherization. There are variations in the cholesterin values, but the changes are not uniform. The specific gravity does not change under light etherization, and under deep anesthesia increases only as asphyxia becomes a factor. The number of red corpuscles, the amount of hemoglobin, and the fragility of the red cells do not change. There is always a leukocytosis in ether anesthesia. The degree of leukocytosis varies from a very slight increase in the number of cells to more than double the normal number. The increase is usually present after from three to four hours of etherization, and is due mainly to cells of the polymorphonuclear form. The leukocytosis is not dependent on the spleen and is not prevented by atropin. It is probably the result of a direct action on the bone marrow. Phagocytic action is certainly not depressed by an etherization period of from five to six hours.

WHILE PURSUING some work on the blood sugar changes in experimental diabetes and in studying the effects of surgical procedures on blood sugar, Albert A. Epstein, of New York City, was impressed with the fact that the hyperglycemia observed was due to a reduction of the blood volume. In consequence he resumed his laboratory experiments and addressing the Fifth Annual Meeting of the American Association of Anesthetists, in New York City, June 2, 1917, and publishing his results in the Anesthesia Supplement of the American Journal of Surgery, October, 1917, detailed the results of his observations on the effects of anesthesia on blood volume.

The subject of traumatic surgical shock has been amply studied by many investigators, and the mechanism which gives rise to its clinical manifestation is now fairly well understood. But in the experimental and clinical observation of this syndrome, we find little evidence of the part played by the anesthetic in its causation.

Shock is essentially a condition of depressed vitality induced by the disturbances of circulation of such a nature that the quantity of blood which reaches the heart is insufficient for the maintenance of life. The ultimate cause of the disturbance is prolonged or excessive irritation of the central nervous system.

In view of the fact that shock has its origin in nerve irritation, the service of an anesthetic in any operative procedure would be primarily to obviate or lessen the tendency to its development; for as we know, anesthesia blocks the afferent nerve paths. However, Henderson[1] in his masterful dissertation on the subject, demonstrates how an anesthesia, when unskillfully given, may not only fail to abolish the tendency to shock, but may render the nerve centers so highly sensitive as to be directly responsible for the production of shock.

Be that as it may, most authors now recognize that the most striking pathological feature of shock is the reduction of the total quantity of blood in the body. Not only is the bulk of the blood in the venous system, but the whole volume of blood is very much diminished. It is for this reason that the clinical effects of shock have so often been likened to those of severe hemorrhage; and it is admitted that the two conditions, shock and hemorrhage, may be clinically indistinguishable. My object in touching upon these points is to bring into relation the chief factors concerned in the production of shock, with some of the striking effects of anesthesia; for anesthesia, as I will presently show, does of itself cause a prompt and considerable reduction in the blood volume.

METHOD OF ESTIMATION.

WHILE PURSUING SOME research work on the blood sugar changes in experimental diabetes[2] I have had occasion to observe that variations in the blood volume occur even in that brief period of anesthesia which precedes the actual operation. These changes were so constant and so striking that subsequently in studying the effect of surgical procedures upon the blood sugar[3] I was forced to the conclusion that the hyperglycemia observed under these conditions was to some extent due to a concentration of the blood, caused by the reduction of the blood volume.

The present communication is based on animal experiments, and observations were made on some forty-one cats. A large number of the animals were studied purely for the effects of the anesthesia on the blood volume, and were permitted to recover without submitting them to surgical manipulations. Others were operated on for various purposes, and determinations of the blood volume were made at different stages of the operations. This afforded an opportunity to observe blood volume changes which occur as a result of the anesthesia alone, and those incidental to the exposure and manipulation of different abdominal organs.

The changes in the blood volume were estimated by means of the method which I have described in the Journal of Laboratory and Clinical Medicine, May, 1916.[4] This method assumes, correctly, I believe, that the total quantity of cells in the blood in one and the same individual does not vary appreciably within short periods of time; and the computation is based on the principle that a change in the relation between the fluid portion and the cell content of the blood is an indication of the change in the total blood volume. In other words, if at the beginning of an experiment the blood shows that the cells occupy 50 per cent. of the total volume in a unit of blood, and one-half an hour later, from one cause or another, the cell content rises to 55 per cent. of the volume, the blood has undergone concentration. The extent to which the volume of blood has become reduced under such conditions is equal to $50/55 = 90$ per cent. Conversely, if the blood cells are found in the second examination to be only 45 per cent. the blood has become diluted, and the increase in the blood volume which can cause such dilution is $50/45 = 110$ per cent.; so that in the first instance we have a reduction in the blood volume from 100 to 90 per cent. of the original volume; in the other we have an increase in the blood volume from 100 to 110 per cent.

Thus, without attempting to establish the exact volume of blood that is in circulation in each in-

1. HENDERSON, YANDELL: 17th Int. Cong. Med., London, 1913; Sub. & Section vii (b) Discussion 3, 49.
2. EPSTEIN, ALBERT A., & BAEHR, GEORGE: J. Biol. Chem., 1916; Vol. xxiv, 1.
3. EPSTEIN, ALBERT A., & ASCHNER, PAUL: J. Biol. Chem., 1916, Vol. xxv, 151.
4. EPSTEIN, ALBERT A.: J. Lab. & Clin. Med., 1916; Vol. i, 610.

dividual case, we can by these simple means determine the exact degree of variation that it may undergo from different influences.

By speaking of concentration of the blood, I mean concentration of the whole blood, and not merely that of a serum or plasma. Concentration or dilution of the serum or plasma may occur as a result of addition or abstraction of soluble solids, without there being any change in blood volume. This distinction is important, because reports based on changes in concentration of the blood serum do not furnish conclusive evidence that the blood volume has been altered thereby. Even changes in viscosity of the blood may lead to incomplete or erroneous interpretation. Thus Burton-Opitz[5] observes that alcohol inhalation raises the viscosity and increases the specific gravity of the blood, and attributes these changes to an accumulation of excretory material in the blood. Whereas this may be true on the basis of the results obtained, another conclusion is admissible, —namely, that the inhalation of alcohol causes a passage of water out of the blood into the tissues. This may cause an increase in the concentration of the serum, and also reduce the whole blood volume.

Sherrington and Copeman[6] have found that in traumatic shock the specific gravity of the blood is markedly increased, and Yandell Henderson[7] interprets these findings as evidence of a decrease in the blood volume.

CHANGES IN THE CELL COUNT AND HEMOGLOBIN.

CHANGES IN THE cell count or in the hemoglobin content of the blood may be regarded as better evidence of volumetric variations of the blood than changes in viscosity or specific gravity, and although these methods have been used in the study of such problems in different experimental investigations, they have not been applied to the study of blood volume in shock. Hence, the validity of the conclusions concerning the reduction of blood volume in shock might be questioned; although most authors agree that in shock the blood volume is very much reduced. Important proof that a state of *oligemia* or reduced blood volume exists in shock is furnished by the work of Mann.[8] From the experiments which he performed this observer draws the conclusion that the clinical signs of shock are due to a loss of circulatory fluid.

To summarize then, it is generally agreed that the most striking change in the blood in the course of shock is the diminution of its volume. This is not regarded as an effect of shock, but rather as one of the potent factors concerned in its development. Nor does this mean that *"the bulk of the blood is transferred from the arterial to the venous system."* It means that the blood content of the entire circulatory system is diminished, not as a result of a change of distribution, or a loss by hemorrhage.

MECHANISM OF REDUCTION.

THE REDUCTION IN blood volume is brought about by a passage of fluid from the blood to the tissues. The mechanism of this may be twofold in character. It may be, as Malcolm[9] believes, due to the spastic state of the smaller arteries and the engorgement of the venous trunks, which leads to a transudation of serum; or as Henderson[10] believes, it may be due to an altered state of the tissues brought about by an acute *acapnia*, or reduced carbon dioxid content of the blood, which causes an increased imbibition of fluid by the tissues.

In the experiments which I have performed, two anesthetics, ether and chloroform, were used. Inasmuch as ether is the anesthetic of choice, both in clinical and experimental work, the larger number of observations were made with this drug. In the present communication the discussion will therefore be devoted to the effects of ether. The results obtained may be divided into

5. Burton-Opitz, R.: Am. J. Phys., 1894; Vol. xxxv, 265.
6. Sherrington & Copeman: J. Phys., 1893, Vol. xiv, 52.
7. Henderson, Yandell: Am. J. Phys., 1910-11; Vol. xxvii, 164.
8. Mann, Frank C.: J. Gynec. & Obst., 1915; Vol. xxi, 430.
9. Malcolm, John D.: Trans. Med. Soc., London, 1909; Vol. xxxii, 274.
10. Henderson, Yandell: Am. J. Phys., 1910-11; Vol. xxvii, 161.

two distinct groups: (1) Those obtained on animals which yielded readily to the anesthetic. (2) Those obtained on animals which proved refractory to the action of the anesthetic. The majority of animals tested reacted normally to the as the effect of the anesthesia wears off. In the second group, that is in animals which cannot be rendered deeply anesthetic, the changes in blood volume are insignificant as shown in Tables III and IV

TABLE I.

Susceptible Animals—Operated—Ether Anesthesia.

Cat No.	Date and Hour.	Per Cent. Plasma Volume.	Per Cent. Cell Volume.	Per Cent. Relative Blood Volume.	Remarks:
5	Oct. 10, 1914				Normal Cat.
	9.43 P.M.	63.5	36.5	100.0	Before anesthesia.
	10.23 P.M.	59.1	40.9	89.2	End of operation for nephrectomy.
		63.9	36.1	101.1	Next morning.
12	Nov. 3, 1913				Normal Cat.
	4.15 P.M.	64.6	35.4	100.0	Before anesthesia.
	5.45 P.M.	57.0	43.0	82.3	End of operation for nephrectomy and pancreatectomy.
20	Dec. 19, 1914				Fasted Cat.
	4.10 P.M.	62.0	38.0	100.0	Before anesthesia.
	4.20 P.M.	58.0	42.0	90.0	During operation.
	4.45 P.M.	56.7	43.3	87.0	End of operation for pancreatectomy and nephrectomy.
	11.00 P.M.	65.2	34.8	108.0	
21	Dec. 19, 1914				Fasted Cat.
	4.55 P.M.	60.9	39.1	100.0	Before anesthesia.
	5.25 P. M.	50.0	50.0	78.2	End of operation for pancreatectomy and nephrectomy.
		64.0	36.0	108.6	16 hours later.
23	Jan. 8, 1915				Fasted Cat.
	2.40 P.M.	57.5	42.5	100.0	Before anesthesia.
	2.55 P.M.	53.0	47.0	90.4	During operation.
	4.10 P.M.	54.2	45.8	93.0	End of operation for pancreatectomy and nephrectomy.
	10.45 P.M.	59.2	40.8	104.0	6½ hours later.
24	Jan. 8, 1915				Normal Cat.
	4.25 P.M.	46.1	53.9	100.0	Before anesthesia.
	5.00 P.M.	43.8	56.2	95.0	End of operation for nephrectomy.
	10.55 P.M.	44.4	55.6	97.0	5 hours later.
	12.30 A.M.	46.1	53.9	100.0	8 hours later.
25	Jan. 9, 1915				Fasted Cat.
	8.15 P.M.	48.7	51.3	100.0	Before operation.
	9.45 P.M.	39.5	60.5	84.0	End of operation for pancreatectomy and nephrectomy.
		51.0	49.0	104.7	Next morning.
26	Jan. 9, 1915				Fasted Cat.
	9.55 P.M.	61.4	38.6	100.0	Before anesthesia.
	10.20 P.M.	57.0	43.0	89.8	End of operation for nephrectomy.
		61.7	38.3	100.8	Next morning.
29	Jan. 25, 1915				Normal Cat.
	8.05 P.M.	48.2	51.8	100.0	Before anesthesia.
	8.42 P.M.	43.3	56.7	91.4	End of operation for nephrectomy.
		48.4	51.6	100.5	Next day.
31	Apr. 19, 1915				Fasted Cat.
	8.40 P.M.	55.2	44.8	100.0	Before anesthesia.
	9.40 P.M.	48.6	51.4	81.0	End of operation for pancreatectomy.
		54.1	45.9	97.9	Next morning.
40	Mar. 9, 1917				Normal Cat.
	1.30 P.M.	57.0	43.0	100.0	Before anesthesia.
	1.45 P.M.	51.2	48.8	88.1	Abdominal incision.

ether. In this group, Tables I and II, the blood volume is promptly affected by the anesthesia. As may be observed, the blood volume becomes reduced, and then gradually returns to normal,

In order to determine whether the blood volume changes bear any definite relation to the susceptibility of the animals to the anesthetic, several tests were made on cats which were at first anesthetized deeply, allowed to recover, and again rendered deeply anesthetic. The results obtained in this set of tests are exemplified by one of the protocols in Table II. These results proved that animals which respond readily to the action of the anesthetic, show a prompt reaction in the blood volume.

The question might naturally arise, whether the changes in the cell content of the blood (upon which the computation of the blood volume depends) observed after the administration of anesthesia, might not be due to an uneven distribution of the cells in the blood. It might be argued that as a result of the change in the tone of the blood vessels (spasm of the smaller arteries) the velocity of the blood might be delayed, and in consequence, circulation of the cellular elements may be impeded. This could give rise to a greater cell concentration in the blood in some parts of the circulation than in others.

To determine this point, the following experiment was performed: A specimen of blood was obtained from the ear vein of a cat, and the cell content determined according to the method described. The animal was then thoroughly anesthetized, and another specimen of blood was obtained at the same point. Directly thereafter, a long incision was made in the abdomen, all of the viscera exposed, and specimens of blood obtained from different localities; and finally by rapid exposure of the thoracic viscera, a blood specimen was also obtained from the heart. All the specimens were examined for the blood cell content, and the results derived, as shown by the protocol in Table V, indicate that the distribution of the cells throughout the circulation is uniform. In other words, the blood is not any more concentrated in one part of the vascular system than in another, under these conditions.

The mechanism which underlies the reduction in the blood volume during narcosis has not been determined in this study. Increased salivary

TABLE II.

Ether Anesthesia—Susceptible Animal—No Operation.

Cat No.		Per Cent. Plasma Volume.	Per Cent. Cell Volume.	Per Cent. Relative Blood Volume.	Remarks:
38	Before anesthesia	58.0	42.0	100.0	
	8 minutes later	55.0	45.0	93.3	lightly under
	21 minutes later	54.3	45.7	91.9	deeply under
	29 minutes later	58.0	42.0	100.0	reacting
	32 minutes later	60.0	40.0	105.0	no anesthesia
	36 minutes later	60.1	39.9	105.0	no anesthesia
	40 minutes later	57.4	42.6	98.6	lightly under
	47 minutes later	55.3	44.7	94.0	deeply under

This protocol shows that in the susceptible animal the blood volume becomes reduced when narcosis is induced, and again returns to normal and even increases temporarily when the anesthesia is stopped. Readministration of the anesthesia causes again a fall in blood volume.

TABLE III.

Refractory Animals—Operated—Ether Anesthesia.

Cat No.	Date and Hour.	Per Cent. Plasma Volume.	Per Cent. Cell Volume.	Per Cent. Relative Blood Volume.	Remarks:
6	Oct. 13, 1914				Normal Cat.
	8.30 P.M.	68.1	31.9	100.0	Before anesthesia.
6	9.10 P.M.	70.4	29.6	102.9	End of operation for nephrectomy.
8	Oct. 22, 1914				Normal Cat.
	9.10 P.M.	57.9	42.1	100.0	Before anesthesia.
	9.50 P.M.	60.0	40.0	105.0	End of operation for nephrectomy.
32	Apr. 19, 1915				Fasted Cat.
	9.45 P.M.	56.3	43.7	100.0	Before anesthesia.
	10.30 P.M.	58.1	41.9	104.3	End of operation for pancreatectomy.

secretion and sweating may be partly responsible for the loss of some fluid from the blood. Boothby and Berry,[11] have demonstrated that muscular work accompanied by sweating is associated with a marked concentration of the blood. That loss of fluid through these channels plays any very great part in the causation of the blood volume reduction seems unlikely from the fact that the animals which are refractory to anesthesia salivate very profusely, and behave in all other respects like the normal animals, but do not show any change in blood volume.

It seems probable that abstraction of fluid by mobilization of the substances from the tissues. From the work of Overton and Meyer,[13] we know that the potency of an anesthetic agent depends upon its power to dissolve fatty and lipoid material, by virtue of which action it can penetrate tissue cells. It would therefore seem that the acidosis and the mobilization of lipoids favor development of a condition in the tissues which renders them partly hydrophilic—that is, capable of absorbing fluid. The work of Herlizka,[14] and that of Koch and Voegtlin,[15] offers additional support to this view. Whether or not an *acapnia*, as Henderson[16] suggests, plays a part in this

TABLE IV.

Ether Anesthesia—Refractory Animal—No Operation.

Cat No.	Duration of anesthesia.	Per Cent. Plasma Volume.	Per Cent. Cell Volume.	Per Cent. Relative Blood Volume.	Remarks:
39	Before anesthesia	60.7	39.3	100.0	
	8 minutes later	59.9	40.1	98.0	lightly anesthetized
	16 minutes later	62.1	37.9	104.0	incompletely anesthetized
	27 minutes later	61.4	38.6	102.0	incompletely anesthetized
	32 minutes later	60.0	40.0	98.2	incompletely anesthetized
	37 minutes later	58.0	42.0	93.0	fairly deep anesthesia
	38 minutes later	61.5	38.5	101.0	anesthesia stopped
	45 minutes later	62.5	37.5	104.8	reacting

This protocol shows that while the animal was refractory no marked change in the blood volume occurred. During the short period of deep anesthesia, however, its blood volume did become considerably diminished

TABLE V.

Cat No.	Source of Blood.	Per Cent. Plasma Volume.	Per Cent. Cell Volume.	Remarks:
27	Ear Vein	45.9	54.1	Animal under ether anesthesia.
	Gastric Vein	45.6	54.4	Results show the uniform distribution of cells and
	Portal Vein	45.9	54.1	plasma in different parts of the circulation.
	R't Aurice	45.8	54.2	
28	Ear Vein	42.9	57.1	Animal under ether anesthesia.
	Portal Vein	42.2	57.7	Results similar to those obtained in above experiment.
	R't Aurice	40.8	59.2	

the tissues from the blood plays the major part in the production of the phenomenon observed. This gains support from other associated conditions which are known to develop in anesthesia. It is now well known[12] that an acidosis develops during narcosis. It is also known that the lipoid content of the blood is increased during anesthesia. This latter phenomenon is ascribed to a process, cannot be determined from the observations which I have made. According to this view, the animals which proved refractory to the anesthetic should have been particular predisposed to showing changes in blood volume. The fact that they fail to show any such variation

11. Boothby, W. M., & Berry, F. B.: Am. J. Phys., 1915; Vol. xxxvii, 378.

12. Morriss, Wm. H.: J. Am. Med. Assn., 1917; Vol. lxviii, 1391.

13. Overton & Meyer, H.: Handbuch d Path. & Pharmak, von R. Heniz, 1904, Vol. i, part 1, 73.

14. Herlizka: Arch. Fisiol., 1909; Vol. xvi, 369.

15. Koch, M. & Voegtlin, C.: Bull. Hygienic Lab., 1916; 103, 129.

16. Henderson, Yandell: l. c. 17th Int. Cong. Med., London, 1913; Sub. & Section vii (b) Discussion 3, 49.

seems to offer a divergence from the view that *acapnia* plays the rôle ascribed to it.

CONCLUSIONS.

THIS STUDY FURNISHES data concerning the effect of anesthesia on the blood volume. In susceptible animals the blood volume is reduced in considerable quantity and very promptly. The difference in respect to the blood volume observed in animals which were anesthetized (and not operated) and those which were subsequently operated on, is one of degrees; for the extent of the reduction of the blood volume in the operated animals is somewhat greater than in the others. This difference cannot be ascribed to a difference in duration of anesthesia, because the change in the blood volume is usually a very prompt one, and prolongation of the anesthesia seems to have little effect upon the phenomenon. On the other hand, recovery from the anesthesia is accompanied by a return of the blood volume to the normal.

In view of the fact that one of the most striking changes in shock is the reduction of blood volume, attention is therefore called to the effect of anesthesia on the blood, because it may initiate the very changes that are acknowledged to be such constant accompaniments of shock.

IN ATTEMPTING TO DETERMINE how anesthetics decrease oxidation, W. E. Burge, of Chicago, Illinois, and his associates, working in the Physiological Laboratory of the University of Illinois, developed some interesting and important data concerning the decrease of blood catalase under anesthesia. Publishing the results of the initial experiments in the American Journal of Physiology, 1917-1918, Burge presented his completed experiences before the Joint Meeting of the Interstate Association of Anesthetists and the Indiana State Medical Association, at Indianapolis, September 25-27, 1918.

Many theories have been advanced in attempts to explain the mode of action of anesthetics in producing anesthesia. Bibra and Harles (1847) held that anesthesia was due to the dissolving and direct removal of the fat-like substances or lipoids from the brain cells by the anesthetic. The rapid recovery alone upon cessation of anesthetization is regarded as sufficient evidence to render this theory untenable. According to the theory of Meyer[1] and Overton[2] the narcotics of the methane series produce their characteristic effect by going into solution in the lipoids of the nervous system. The fact that there are so many anesthetics that do not belong to the methane series and are not fat solvents (nitrous oxid and magnesium sulphate being examples), would seem to indicate that the Meyer-Overton theory, while explaining how the narcotics obtain access into the nerve cells, does not explain how anesthesia is produced.

Paul Bert[3] and Arloing[4] showed that oxidation was decreased during anesthesia and that this decrease was more extensive with a powerful anesthetic, such as chloroform than with a less powerful anesthetic, such as ether. Verworn[5] and his pupils consider that anesthesia is due to decreased oxidation, while Crile[6] claims that it is due to the acidosis arising from the diminished or defective oxidation.

As a result of the work of Paul Bert, Arloing, and particularly of Alexander and Cserna[7], it is now generally accepted that the initial effect of anesthetics on the respiratory exchange is to cause an increase in oxygen consumption and carbon dioxid production; however, after the preliminary stimulating action has passed the

1. MEYER: Arch. f. exper. Path. u. Pharm., 1899.
2. OVERTON: Studien über die Narkose, Jena, 1901.
3. BERT: Dastre, Les Anaesthesiques, Paris, 1890.
4. ARLOING: Ibid.
5. VERWORN: Narkose, Jena, 1912; Narcosis, Harvey Lect., 1912, 152.
6. CRILE: The Origin and Nature of the Emotions, 1915.
7. ALEXANDER AND CSERNA: Biochem. Zeitschr., 1913, Vol. liii, 101.

effect is to produce a decrease in the consumption of oxygen and the production of carbon dioxid, so on the whole it may be said that anesthetics produce a decrease in the respiratory exchange. These observations indicate that during the excitement stage of ether anesthesia oxidation in the body is increased, while during the rest of the stages it is decreased. The fall of body temperature during anesthesia, the occurrence of acetone in the breath and urine,[8] the appearance of glycosuria[9], the increase in unoxidized sulphur[10], are taken as further evidence that the oxidative processes are decreased or rendered defective by anesthetics.

It has been shown in this laboratory that when oxidation is increased or decreased in an animal by increasing or decreasing the amount of exercise, by thyroid feeding or by the fighting emotions, there is a corresponding increase or decrease in the catalase of the muscle, hence the conclusion was drawn that there exists a very close relationship between catalase content and amount of oxidation. Evidence was also presented to show that catalase formed in the liver and given off to the blood during exercise, and in combat, is carried to the muscles and used in the increased oxidation, presumably making it possible, and that the output from the liver is controlled by stimuli received over the splanchnics.[11]

The present investigation was begun in an attempt to obtain further evidence regarding the production and function of catalase. If catalase is concerned in oxidation then the amount in an animal should be increased during the excitement stage of ether anesthesia and decreased during the other stages, since oxidation is increased during the excitement stage and decreased during the other stages. Dogs and cats were the animals used in this investigation. The amount of catalase in the blood was determined according to the following method. One-half cubic centimeter of blood was added to hydrogen peroxid in a bottle and the oxygen gas liberated in ten minutes was conducted through a rubber tube to an inverted vessel previously filled with water. After reducing this volume of gas to standard atmospheric pressure the resulting volume was taken as a measure of the catalase content of the 0.5 cc. of blood. In determining the catalase content of the blood of dogs 45 cc. of hydrogen peroxid were used and in determining that of cats 500 cc. The larger amount of peroxid was used in the case of cats because of the high catalase content of their blood. The hydrogen peroxid used in all these determinations was prepared by diluting commercial hydrogen peroxid with an equal volume of distilled water.

THE EFFECT ON CATALASE OF INCREASING AND OF DECREASING THE DEPTH OF ANESTHESIA.

THE DATA IN Table I were obtained from dogs that had been injected with morphin and slightly etherized previous to the introduction of the cannula into the trachea. The tracheal cannula was connected by means of a rubber tube with an ether bottle and the apparatus so arranged that the amount of air and ether administered could be changed at will. Immediately after introducing the cannula into the trachea about 3 cc. of blood were taken by means of a hypodermic syringe from the external jugular and the amount of catalase in 0.5 cc. of this blood was determined according to the method given. Similarly determinations were made after 15, 30 and 45 minutes respectively. These data are given in Table I *under administration of ether.* The dogs were regarded as being in the first stage of ether anesthesia immediately after the introduction of the tracheal cannula, and in the second, third and fourth stages after 15, 30 and 45 minutes respectively. These different stages were chosen more or less arbitrarily and used as a convenient method for the presentation of the results. During the fourth stage

8. Baldwin: Journ. Biol. Chem., 1905, Vol i, 239.

9. Hegar and Kaltenbach: Virchow's Arch. f. path. Anat., 1870, Vol. xlix, 437.

10. Kast and Mester: Zeitschr. f. physiol. Chem., 1887, Vol. xi, 277.

11. Burge, Neill, and Kennedy: The American Journal of Physiology, 1916, Vol. xli, 153; 1917, Vol. xliii, 58; 1917, Vol. xliii, 433; 1917, Vol. xliii, 545; 1917, Vol. xliv, 290; 1918, Vol. xlvii, 13; Arch. Int. Med., 1917, Vol. xx, 892; Science, 1917, N. S., Vol. xlvi, No. 1192, 440; 1917, N. S., Vol. xlvi, No. 1199, 618; 1917, N. S., Vol. xlviii, No. 1239, 327.

the dogs were very deeply under the ether and had almost ceased to breathe. After taking the blood sample for this stage the apparatus was so adjusted that air containing but little ether was administered and the animal was permitted slowly to recover from anesthesia. During this period of recovery determinations were also made of the catalase content of the blood at intervals of about 15 minutes. The results of these determinations are given in the table under *recovery from ether.* The catalase of the blood of a cat was also determined during the period of *administration of ether.*

TABLE I.

Under the different stages are given the number of cubic centimeters of oxygen liberated in ten minutes from hydrogen peroxid by 0.5 cc. of blood of dogs and cats in the respective stages of anesthesia.

Animals	Administration of Ether					Recovery from Ether				
	First stage	Second stage	Third stage	Fourth stage	Percentage decrease	Fourth stage	Third stage	Second stage	First stage	Percentage increase
Dog 1	70	65	55	48	32	48	60	68	75	56
Dog 2	62	60	53	42	29	42	45	60	59	40
Cat 1	875	775	725	600	31					

TABLE II.

Under "normal" and "exposed to ether" are given the number of cubic centimeters of oxygen liberated from hydrogen peroxid in ten minutes by 0.5 cc. of dog's blood and cat's blood exposed to ether vapor for the respective intervals of time. Under "bubbling of air" are given tbe amounts of oxygen liberated by the blood previously exposed to etber that had had air bubbled through it for the respective periods.

	Normal	Exposed to Etber				Percentage decrease	Bubbling of Air			
		60′	120′	180′	240′		60′	120′	180′	240′
Dog blood:										
Specimen 1....	65	55	44	44	40	40	42	40	38	40
Specimen 2....	60	51	42	40	38	36	38	40	37	36
Average	63	53	43	42	39	38	40	40	37	38
Cat blood:										
Specimen 1....	875	775	725	600	575	34	575	525	565	500

It will be seen that the catalase content of the blood decreased during the periods of administration of ether, as is indicated by a decrease in the amount of oxygen liberated, and increased during the periods of recovery from ether, and that the catalase was decreased by about 30 per cent. in the fourth stage during the administration of ether and had returned almost to the normal amount in the first stage of anesthesia during the period of recovery from ether. The question that naturally suggests itself in this connection is, does the ether during the period of administration destroy the catalase of the blood or simply inhibit its action so that during the period of recovery when the ether is removed from the blood the catalase returns to its normal strength? The following experiments were carried out in an attempt to answer this question.

THE EFFECT ON CATALASE OF EXPOSING BLOOD IN VITRO TO ETHER VAPOR UNDER PRESSURE.

TWO DOGS WERE quickly etherized and bled to death. The defibrinated blood from these animals was exposed to ether vapor under a pressure of 10 mm. of mercury at 36°C. for 60, 120, 180 and 240 minutes respectively. The catalase content of the unexposed blood and of the blood exposed for the different periods was determined. Results of these determinations are given in Table II, under *dog blood,* after specimens 1 and 2. It will be seen that the average amount of oxygen liberated by 0.5 cc. of the normal or unexposed blood was 63 cc., that liberated after exposure of blood to ether vapor for

60, 120, 180 and 240 minutes respectively was 53, 43, 42 and 39 cc. of oxygen, hence the catalase content of the blood was decreased by about 38 per cent. as is indicated by a decrease from 63 to 39 cc. of oxygen. The blood of a cat was similarly exposed and the results are given in the table under *cat blood*. It will be seen that the exposure of cat blood to ether vapor decreased the catalase content by about 34 per cent. In performing the preceding experiment great care must be taken to see that none of the liquid ether comes in contact with the blood for this will destroy the catalase very quickly. Other experiments were carried out in which the catalase of the blood was lowered by administering ether to the animal. When the catalase was decreased by about 40 per cent. which was determined from a sample of blood taken from the jugular, the animal was bled to death. After defibrination one sample of the blood was exposed to a vacuum to remove the absorbed ether; oxygen gas was bubbled through another and air through another. The catalase of the blood was not increased by any of these treatments, as is the case when animals are permitted to recover from ether by breathing air. The conclusion is drawn that the decrease in the amount of catalase in the blood of animals during the period of administration of ether is due to a destruction of the catalase and not to an inhibition of its activity. The following experiments were carried out in an attempt to find an explanation for the increased catalase content of the blood during the period of recovery from ether.

THE EFFECT OF STIMULATING THE SPLANCHNICS ON THE OUTPUT OF CATALASE FROM THE LIVER.

WHEN THE DOG was well under ether, or in what is referred to as the third stage of anesthesia in Table III, the abdominal wall was opened and a sample of blood was taken from the hepatic vein and the catalase content of 0.5 cc. of this determined. The two splanchnic nerves were then dissected out where they emerge from under the diaphragm and shield electrodes placed on them. Very weak stimuli from an induction coil were applied for about five seconds at intervals of about fifteen seconds. This intermittent stimulation was continued for about fifteen minutes. At the end of this time another sample of blood was taken from the hepatic vein and the catalase content of 0.5 cc. determined. Similarly determinations were made at the end of 30, 45 and 60 minutes of stimulation. The results of the determinations are given in Table III under third stage of anesthesia and 15, 30, 45 and 60 minutes of stimulation of splanchnics. It will be seen that the average amount of oxygen liberated by 0.5 cc. of blood from dogs in the third stage of anesthesia was 49 cc., that liberated after stimulating the splanchnics for 15, 30, 45 and 60 minutes was 62, 63, 68 and 69 cc. respectively. This is taken to mean that the stimulation of the splanchnics increased the output of catalase from the liver by about 40 per cent. Precaution of course was taken to see that the animal was kept in about the same state of anesthesia throughout the experiment. The following experiment was carried

TABLE III.

Under "third stage of anesthesia" and periods of "stimulation of splanchnics" are given the number of cubic centimeters of oxygen liberated from 50 cc. of hydrogen peroxid in ten minutes by 0.5 cc. of blood from dogs in the third stage of anesthesia and with their splanchnics stimulated for the respective periods.

Dog	Third stage of anesthesia	Stimulation of Splanchnics				Percentage increase
		15′	30′	45′	60′	
Dog 1	48	57	54	60	61	27
Dog 2	50	68	70	75	70	40
Dog 3	50	60	65	70	75	50
Average	49	62	63	68	69	39

out to determine if it was possible to increase the output of catalase from the liver by prolonging the period of excitement in ether anesthesia.

THE EFFECT ON CATALASE OF PROLONGING THE EXCITEMENT STAGE IN ETHER ANESTHESIA.

ETHER WAS ADMINISTERED to a dog by placing over the nose of the animal a cone-shaped vessel attached to an ether bottle by a rubber tube. A large amount of air was mixed with the ether so that the dog struggled during its administration. After permitting the animal to struggle about twenty minutes during the administration of this mixture the supply of air was decreased and the amount of ether was increased. As soon as the dog was etherized a sample of blood was quickly taken from the hepatic vein and the catalase content of 0.5 cc. of the sample determined. Similarly determinations were made of the catalase of the blood of two other dogs which had struggled violently during the excitement stage of the administration of ether and of two dogs which had been injected with morphin previous to the administration of ether. In the morphinized animals there was very little or no excitement stage during the administration of ether. The results of the determinations are given in Table IV. It will be seen that the average amount of oxygen liberated by 0.5 cc. of blood from the dogs in which there was very little or no excitement stage of anesthesia was 66 cc. while the average amount liberated by the dogs in which the excitement stage of anesthesia had been prolonged was 162 cc. These results are interpreted to mean that the struggle during the administration of ether had increased the output of catalase into the blood in a manner similar to what occurs in combat. We have determined in connection with another problem the catalase content of the blood of at least forty dogs that had been morphinized previous to etherization and 0.5 cc. of the blood of none of these animals liberated more than 70 cc. of oxygen from 50 cc. of hydrogen peroxid, so that we are satisfied that the catalase content of the blood of dogs that do not undergo the prolonged and violent excitement stage of anesthesia is low.

It is assumed that the increase in the catalase of the blood during recovery from ether is brought about in the same manner that it is by prolonging the excitement stage of ether anesthesia or by stimulating the splanchnics, namely, by increasing the output of catalase from the liver into the blood.

The fact that unconsciousness follows very quickly after cutting off the blood supply to the brain and that the conductivity of a nerve is suspended when deprived of oxygen indicates that oxygen is very essential in the normal functioning of nervous tissue, as in other tissue. Oxygen, *per se*, of course is not the essential thing but oxidation. When the brain or a nerve is deprived of oxygen there is a decrease in oxidation and an increase in incompletely oxidized substances resulting in an interference with normal functioning. The fact that ether destroys the catalase of the blood and presumably of the nervous tissue, thus producing a decrease in oxidation, suggests that this effect may be the means by which ether produces anesthesia. It is recognized that chloroform is a more powerful and a more dangerous anesthetic than ether. In some unpublished results we observed in chloroform poisoning that the catalase of the liver as well as of the blood was decreased, as is the case in phosphorus poisoning. The more powerful effect of chloroform as an anesthetic may be due to its harmful effect on the liver whereby the output

TABLE IV.

Under "normal" and "prolonged excitement" are given the number of cubic centimeters of oxygen liberated in ten minutes from 50 cc. of hydrogen peroxid by 0.5 cc. of blood of normal dogs and of dogs which had undergone an excitement stage of about twenty minutes at the beginning of the administration of ether.

Dog	Normal	Prolonged excitement	Percentage increase
Dog 1	68	152	123
Dog 2	72	199	210
Dog 3	60	136	126
Average	66	162	153

of catalase from this organ is decreased in addition to the destructive effect on the catalase of the blood. According to the above hypothesis the decrease in oxidation in the nerve centers is produced by the destruction of catalase by the anesthetic thus bringing about the depressed condition of the nervous system or anesthesia. On cessation of the administration of the anesthetic facts we have at the present time bearing out this hypothesis are enumerated in the conclusions.

CONCLUSIONS.

1. The catalase content of the blood decreases during the administeration of ether and increases during the recovery from ether. The decrease is due to the destruction of catalase by ether, the

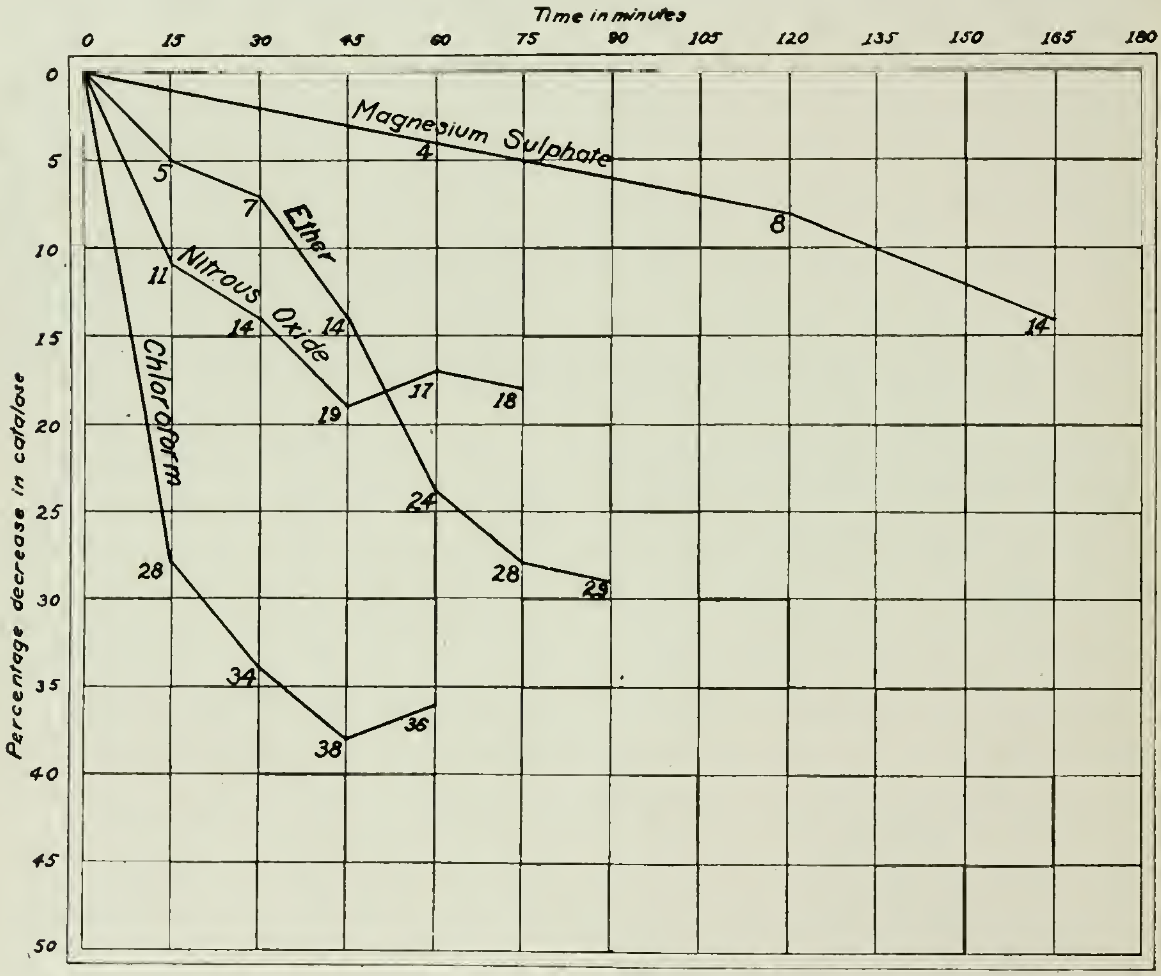

Figure 1.

the amount of catalase in the center is increased owing to absorption of catalase from the blood and hence oxidation is increased. With increased oxidation in the centers irritability returns, the splanchnics again take up their function in producing an increased output of catalase from the liver into the blood. The experimental increase to an increased output of catalase from the liver. The decrease in catalase during the administration of ether may be the cause of the decreased oxidation during anesthesia, while the increased output of catalase from the liver during recovery may account for the increased oxidation during this period.

2. Blood catalase is destroyed *in vitro* by exposure to ether vapor as happens *in vivo* during the administration of ether; however, in the former case catalase is not restored to the normal amount when the ether is removed by bubbling air or oxygen through the blood as occurs *in vivo* when the animal is permitted to recover from the effect of ether by breathing air.

3. The catalase content of the blood can be increased by prolonging the excitement stage of ether anesthesia or by stimulating electrically the splanchnic nerves distributed to the liver. The increase in catalase may account for the increased oxidation during the excitement stage of ether anesthesia just as the decrease in catalase may account for the decreased oxidation during the rest of the stages.

REDUCTION OF CATALASE BY VARIOUS ANESTHETICS.

FURTHER EXPERIMENTS WERE conducted along similar lines to determine the comparative reduction of catalase by various anesthetics.

The anesthetics used were ether, chloroform, nitrous oxid and magnesium sulphate. These widely different kinds of narcotics were chosen intentionally. The chloroform and ether were administered by bubbling air through these anesthetics in a bottle which was connected by a rubber tube to a cone adjusted to the snout of the animal; the magnesium sulphate anesthesia was produced by the subcutaneous injection of 7.5 cc. of a 20 per cent. magnesium sulphate solution per kilogram of body weight, and the nitrous oxid anesthesia by administering a mixture of nitrous oxid in the proportion of 1 to 5, or 80 per cent. nitrous oxid and 20 per cent. oxygen. The results of the determinations are given in Figure 1. The figures (0-180) along the abscissa indicate time in minutes; the figures (0-40) along the ordinate indicate percentage decrease in catalase.

The curves in Figure 1, marked chloroform, nitrous oxid, ether, and magnesium sulphate were constructed from data obtained from cats during anesthesia produced by these different anesthetics. It will be seen that chloroform decreased the catalase of the blood 28 per cent. during the first fifteen minutes of anesthesia, 34, 38 and 36 per cent. during the succeeding fifteen minute intervals. Nitrous oxid decreased the catalase of the blood 11 per cent. during the first fifteen minute interval, 14, 19, 17 and 18 per cent. during the succeeding fifteen minute intervals. By examining the curves marked ether and magnesium sulphate, the rate and extent to which these anesthetics decreased catalase may be seen.

If narcosis is due to decreased oxidation and if this decreased oxidation in turn is due to a decrease in catalase then the destructive effect of an anesthetic on catalase should be an index to the character of anesthesia produced by the anesthetic in question. By comparing the rate and extent of decrease produced by the different anesthetics used it may be seen that chloroform, in keeping with its rapid and powerful action, decreased the catalase of the blood most extensively and abruptly; that nitrous oxid, in keeping with its rapid, but less powerful action, produced a very abrupt decrease, but not such an extensive one; while, ether, in keeping with its more powerful, but less rapid action, produced a more extensive, but less abrupt decrease than did nitrous oxid; magnesium sulphate decreased the catalase of the blood very slowly, and not very extensively.

It should be said in this connection that no attempt was made in the experiments described to administer the anesthetics in equimolecular concentrations. All except the magnesium sulphate were administered in sufficient concentrations to produce a fair degree of anesthesia by the end of the first fifteen minute interval, and the amount administered during the remaining periods was such as to keep the animal in fairly deep but safe narcosis. We have found that by choosing large, active cats with blood of high catalase content, and by forcing the anesthetic it was possible to decrease the catalase much more quickly and extensively than was done in the preceding experiments, but even in these cases it was found that the same relationship held; that is, chloroform produced a more abrupt and extensive decrease in catalase than did nitrous oxid or ether: while the nitrous oxid produced a more abrupt but less extensive decrease than did ether. We also found that when the catalase had been decreased as far as it could be by the use of nitrous oxid, it could be decreased considerably more by changing to chloroform. It may be that the greater tendency toward acidosis in chloroform narcosis is due to this greater destruction of catalase with resulting decrease in oxidation, and to the greater injury of the liver, the organ in which catalase is formed.

SUMMARY.

1. Narcotics of widely different constitution, such as chloroform, ether, nitrous oxid and magnesium sulphate, decrease the catalase of the blood, parallel with the increase in the depth of narcosis.

2. A very powerful anesthetic, such as chloroform, decreases the catalase more quickly and extensively than does a less powerful anesthetic, such as ether. Slowly acting anesthetics, such as magnesium sulphate, decrease, accordingly, the catalase of the blood more slowly than a quickly acting anesthetic such as nitrous oxid.

3. As a result of the experiments reported in this paper, and of work done previously on the anesthetics in this laboratory, the theory is advanced that narcosis is primarily due to the decrease in catalase produced by the decreased output from the liver, and by the destruction of catalase by the narcotic, with resulting decrease in oxidation and increase in acidosis.

I HAVE HAD THREE PERSONAL IDEALS: ONE TO DO THE DAY'S WORK WELL AND NOT TO BOTHER ABOUT TOMORROW. YOU MAY SAY THAT IS NOT A SATISFACTORY IDEAL. IT IS; AND THERE IS NOT ONE WHICH THE STUDENT CAN CARRY WITH HIM INTO PRACTICE WITH GREATER EFFECT. TO IT MORE THAN ANYTHING ELSE I OWE WHATEVER SUCCESS I HAVE HAD—TO THIS POWER OF SETTLING DOWN TO THE DAY'S WORK AND TRYING TO DO IT WELL TO THE BEST OF MY ABILITY AND LETTING THE FUTURE TAKE CARE OF ITSELF. THE SECOND IDEAL HAS BEEN TO ACT THE GOLDEN RULE, AS FAR AS IN ME LAY, TOWARD MY PROFESSIONAL BRETHREN AND TOWARD THE PATIENTS COMMITTED TO MY CARE. AND THE THIRD HAS BEEN TO CULTIVATE SUCH A MEASURE OF EQUANIMITY AS WOULD ENABLE ME TO BEAR SUCCESS WITH HUMILITY, THE AFFECTIONS OF MY FRIENDS WITHOUT PRIDE AND TO BE READY WHEN THE DAY OF SORROW AND GRIEF CAME TO MEET IT WITH THE COURAGE BEFITTING A MAN.

—*William Osler.*

VASCULAR REFLEXES WITH VARIOUS TENSIONS OF ETHER VAPOR . EXPERIMENTAL METHODS OF PROCEDURE . CONSTANCY OF PHYSIOLOGIC PHENOMENA UNDER SIMILAR TENSIONS . OPTIMUM TENSIONS FOR OPERATIVE WORK . EFFECTS ON REFLEXES AND BLOOD PRESSURE . PRESSOR AND DEPRESSOR RESPONSES . CONCLUSIONS . THE EFFECTS OF ETHER ANESTHESIA AND OF VISCERAL TRAUMA AS SHOWN BY VASOMOTOR AND BLOOD PRESSURE CHANGES . POINTS UNDER DISCUSSION . METHODS OF EXPERIMENTATION AND RESPECTIVE RESULTS . EFFECTS OF TRAUMA . RELATION OF STIMULATION AND EXHAUSTION AND THE SURGICAL APPLICATION.

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THE INCOMPLETE STUDIES of Walter M. Boothby, of Boston, Massachusetts, on ether percentages and tensions, have enabled Frank C. Mann, of Rochester, Minnesota, to continue researches along the same lines to determine to what degree blood pressure and the vascular reflexes are modified by the different tensions of ether and to establish an optimum range of tensions for these reflexes. He submitted the details of his findings in the Laboratory of Surgical Physiology of the Mayo Clinic, to the American Association of Anesthetists, during the Fifth Annual Meeting in New York City, June 2, 1917, and published them in the Journal of the American Medical Association and the Anesthesia Supplement, 1917.

The study of ether percentages by Boothby,[1] who showed that in man all individuals become anesthetized at a definite tension of ether, and the introduction by Connell,[2] of the anesthetometer, an instrument adopted to accurately administer definite and known tensions of ether, have opened a new field for the investigation of physiological phenomena in relation to anesthesia. This is of importance, not merely in regard to the process of anesthesia but also in regard to the many physiological problems, the study of which compels the use of an anesthetic.

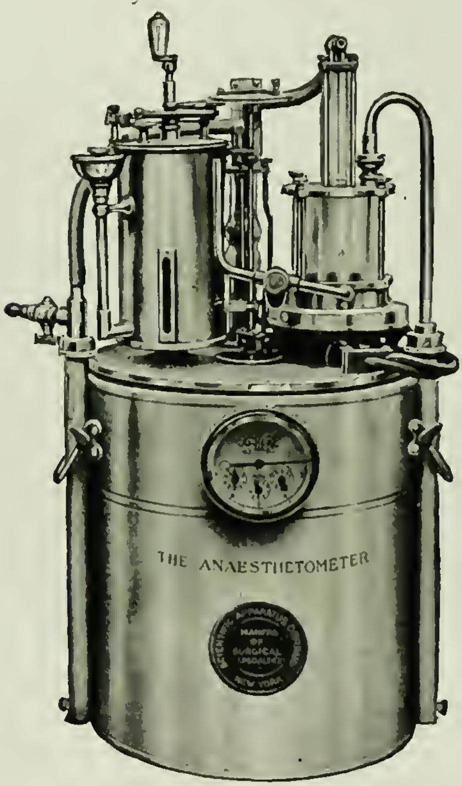
The physiological investigator employing anesthetized animals has usually been content to state that the animal was lightly anesthetized or deeply anesthetized as the case might be. While this may mean a fair degree of accuracy by each individual investigator for any particular series of experiments it certainly does not mean the same in all instances because what might be a lightly anesthetized animal to one would appear deeply anesthetized to another. Furthermore, difficulty is experienced in attempting to corroborate the work of any investigator because of the anesthetic factor. This has been repeatedly emphasized by Boothby.

The non-standardized state of anesthesia in regard to physiological research has probably been partially responsible for contradictory data concerning different problems. It has undoubtedly been a factor in the shock problem and may be responsible for some of the debated problems in regard to blood pressure and respiration.

1. Boothby, W. M.: Ether Percentages. Jour. Am. Med. Assn., 1913, Vol. lxi, 830-834.
2. Connell, K.: An Apparatus (Anesthetometer) for Measuring and Mixing Anesthetics and other Vapors and Gases. Surg. Gynec. and Obst., 1913, Vol. xvii, 245-255.

The present research was undertaken to determine to what degree blood pressure and the vascular reflexes are modified by the different tensions of ether, and to establish an optimum range of tensions for these reflexes.*

The particular Connell apparatus obtained was made by a new manufacturing company and was not mechanically correct. When calibrated by the method described by Boothby and Sandiford[3] it was found to deliver a tension considerably less than it was supposed to be standardized for and there was a wider range of variation than desired. It is hoped that an instrument which can be calibrated as closely as Dr. Boothby's will be secured for finishing the problem.



The Perfected Type of Connell Anesthetometer.

*When I first thought of working with the Connell apparatus I intended to establish a standard of ranges of anesthetic tension for each species of the common laboratory animals. One range would include the optimum tension for physiological work and another the tensions which are liable to prove fatal. In a discussion of the subject with Dr. W. Boothby he suggested that I finish a problem which he had started with Dr. W. T. Porter, in regard to the vascular reflexes with various tensions of ether. Unfortunately Dr. Boothby was called to the war before the work was completed. For this reason, as well as the fact that the particular instrument used was found to have a rather large coefficient of error, this paper must be considered as a preliminary report.

3. Boothby, W. M., and Sandiford, I.: The Calibration of the Waller Gas Balance and the Connell Anesthetometer. Jour. Pharm. and Exper. Therap., 1914, Vol. v, 369-378.

The tensions found necessary for work on the dog as used on the apparatus were between 40 and 64. These available tensions when calibrated by means of the Waller gas balance were found to have approximately the following values:

Tension on Connell.	Tension on Waller.
40	36.4
44	38.1
47	43.6
51	44.1
53	49.2
54	48.4
58	50.7
61	54.5
64	55.1

I am indebted to Miss Sandiford for invaluable aid in calibrating the apparatus.

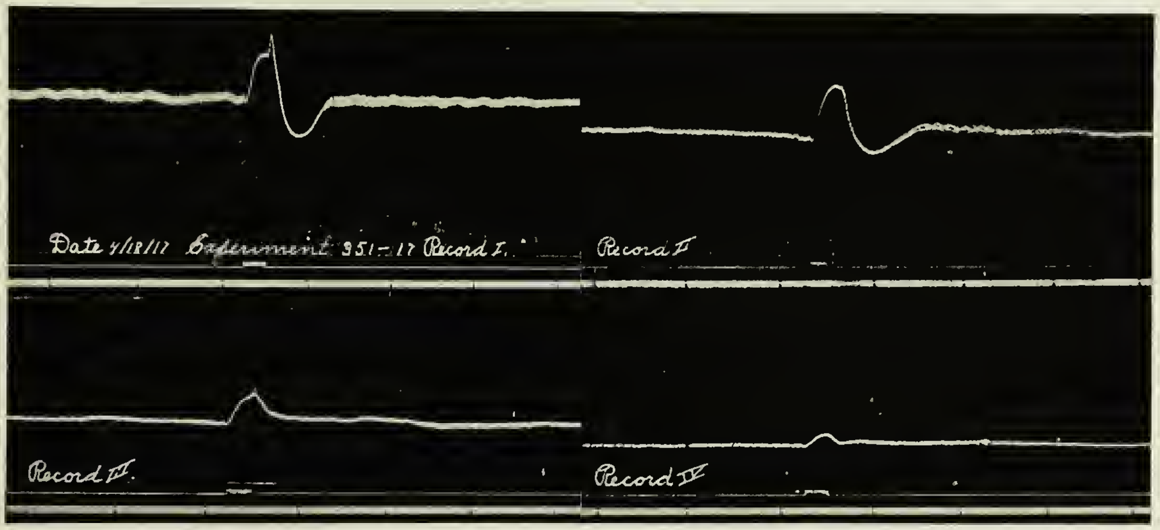
In the calibration no account was taken of the alcoholic content of the ether and the apparatus was run in practically the same manner as used in the experiments. While there was considerable variation the actual tension of ether must have been very nearly that computed on the Waller balance. Owing to this wide variation of tensions due to the apparatus, only approximate tensions will be given now and later I hope to check them with a more accurate instrument. The experimental results will be expressed in approximately the corrected tensions.

EXPERIMENTAL METHODS OF PROCEDURE.

ALL EXPERIMENTS WERE performed on dogs. The animals were etherized by means of a cone or cabinet and after intubating a definite tension of ether was administered. This was usually the lowest tension compatible with operative work. The apparatus was arranged to record carotid blood pressure (mercury manometer) and respiration. The desired nerves were carefully prepared in the usual manner and all precautions were taken to preserve them in a normal condition. All stimulating was done with a platinum or shield electrode and a Kronecker inductorium using a primary current derived from storage batteries. While no effort was made to standardize the stimulus, great care was taken to keep it constant for each experiment. When pressor reflexes were desired, the strength enough to seriously affect the general results.

One hour was arbitrarily chosen as the time necessary for the ether in the tissues to reach the same tension as in the alveolar air. From the careful observations in these experiments I believe that one hour is fully ample. Care was taken not to fill the apparatus within 15 minutes before stimulating.

After administering the anesthetic at a constant tension for one hour the nerves were stim-



Experiment 351-17. Kymograph record showing effect of various tensions of ether on the pressor reflex of the vagus. There was an interval of one hour between each record. Nerve stimulated: Central end left vagus; right vagus sectioned.

	Ether tensions (Approximate)	*Blood pressure reaction*
Record I	36	Increased from 138 to 194 then dropped to 105.
Record II	43	Increased from 104 to 150 then dropped to 90.
Record III	48	Increased from 54 to 80, maintained.
Record IV	50	Increased from 35 to 48, maintained.

of stimulus and rate were made far above the threshold for these reflexes. Both were decreased for depressor reflexes.

Vascular reflexes obtained in an animal with intact respiratory mechanism are affected by the changes in respiratory movements. To obviate this curare was used in a few experiments but it was found that even with the greatest care the product which can be obtained now was too toxic. However as this is only a comparative study for each animal the respiratory factor is not great ulated for a definite time, usually fifteen or thirty seconds, and the changes in blood pressure and respiration recorded. Then the ether was changed to another tension. After all the desired tensions were used the animal was either given air or a very low tension and the nerves stimulated. This was done in order to be sure that the nerves were still functionating. However, the results show that on the whole this was not necessary because in only two experiments were the nerves found to be badly injured.

CONSTANCY OF PHYSIOLOGIC PHENOMENA UNDER SIMILAR TENSIONS.

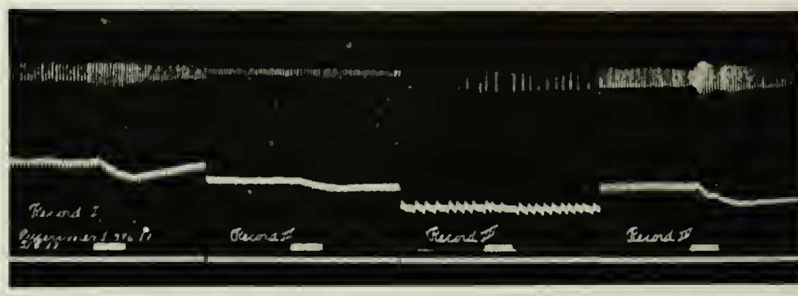
IN GENERAL, THE physiologic phenomena occurring under ether were found to be remarkably constant at the same tension in different dogs.[4] While the effects of different tensions upon blood pressures, the vascular reflexes, respiration and the respiratory reflexes were not always progressive or absolutely constant, yet there were certain narrow limits of tension within which certain changes always occurred. However, with a very accurate apparatus I believe all the reflexes will be found to be proportioned to the anesthetic tension used.

It was found that the lowest tension compatible with operative work on the dog was approximately 36. At this tension all the operative procedures necessary for the experiment could be carried out but the animal was always very lightly anesthetized and it was usually necessary to administer the ether for over half an hour at this tension before beginning work. This tension was too low for satisfactory routine work.

OPTIMUM TENSIONS FOR OPERATIVE WORK.

THE OPTIMUM TENSIONS for operative work are probably between 38 and 45. At these tensions the animal reacts slightly to operative procedures but the condition remains excellent. As the ether tension is increased above 36 the animal progressively exhibits the signs of deepening anesthesia but the condition remains good until a tension of 48 is reached. The range of ether tension between 36 and 48 is the range of surgical anesthesia in the dog. While blood pressure and respiration may both be greatly depressed it seems impossible to kill an animal with any tension within this limit provided time is not allowed to become a factor.

When the tension is increased above 48 the animal becomes profoundly anesthetized and respiration is liable to fail and blood pressure to decrease to a very low level. This may occur at any tension above 48 and 60, but usually it takes place at tensions between 50 and 55. In all probability a dog cannot withstand a tension above 60. None in my series has ever been able to withstand a tension of 60. The range of ten-



Experiment 396-17. Kymograph record showing effect of various tensions of ether on depressor reflex of sciatic. There was an interval of one hour between each record. Nerve stimulated: Central end right sciatic.

	Ether tensions (Approximate)	*Blood pressure reaction*
Record I	36	Decreased from 100 to 78.
Record II	43	Decreased from 80 to 70.
Record III	44	No change.
Record IV	Air	Decreased from 70 to 50.

Note that the reflex disappears under a relatively low tension.

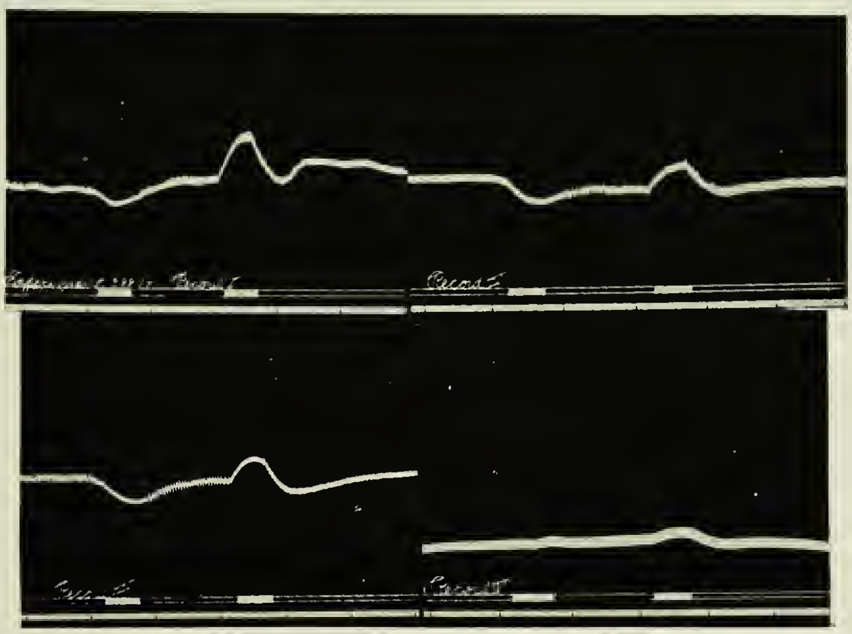
4. This corresponds to the results of Boothby in man.

4. BOOTHBY, W. M.: The Determination of the Anesthetic Tension of Ether Vapor in Man, with some Theoretical Deductions therefrom, as to the Mode of Action of the Common Volatile Anesthetic. Jour. Pharm. and Exper. Therap., 1914, Vol. vi, 379-392.

sions between 48 and 60 is the limit of viability for the dog. Any tension within this limit may prove fatal to the animal.

The corneal reflex is very active at tensions 36 to 40. Under a tension slightly above 40 it may disappear. It probably never persists at tensions above 45.

ular for that tension. It may remain at about the same level or be successively slightly decreased at each increase of tension until a tension of 48 is reached. It is always greatly decreased by tensions above 48 but usually does not reach zero at tensions less than 50 and rarely persists at a tension of above 55.



Experiment 399-17. Kymograph record showing the effect of various tensions of ether on depressor and pressor reflexes produced by stimulating the same nerve with different strength and rate of stimuli. There was an interval of one hour between each record. Nerve stimulated: Central end of left vagus. Right vagus sectioned. Stimulus: Primary current derived from storage battery. Depressor response produced with secondary coil at 16, rate 4. Pressor response produced with secondary coil over primary, rate 24 to 30.

	Ether tensions (Approximate)	*Blood pressure reaction*
Record I	36	Decreased from 108 to 92. Increased from 129 to 166.
Record II	43	Decreased from 120 to 94. Increased from 105 to 130.
Record III	44	Decreased from 130 to 108. Increased from 128 to 150.
Record IV	48	Barely perceptible rise. Respiration gone. Increased from 60 to 66.

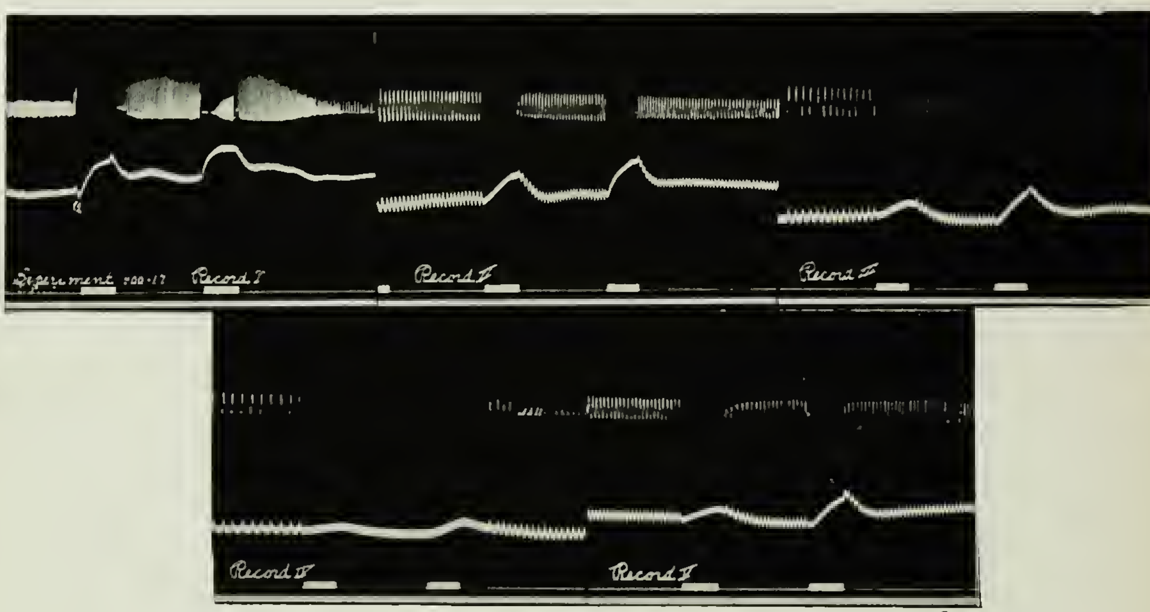
Note that the depressor reflex and respiration disappeared while the pressor was still active.

EFFECTS ON REFLEXES AND BLOOD PRESSURE.

THE BLOOD PRESSURE usually varies considerably under a tension of 36 because of the lightly anesthetized state of the animal. Under all increased tensions it remains very reg-

In a few experiments the blood pressure slightly increased as the ether tension was increased until 48 to 50 was reached when it decreased very markedly.

The changes in blood pressure under the different tensions of ether depend somewhat upon the initial pressure. When the pressure under 36 is high each increase in tension may produce a definite decrease in the pressure. In the experiments in which the pressure under 36 was low, the first few increases in the ether tension did and even though ether be withdrawn and air administered until the anesthesia becomes so light that it is necessary to administer more ether, blood pressure only partially recovers. This result was probably due not only to the anesthetic but also to the long continued low blood pressure.



Experiment 400-17. Kymograph record showing effect of various tensions of ether, on the vascular and respiratory reflexes of the vagi. There was an interval of one hour between each record. Nerves stimulated: Central ends of right and left vagi.

	Ether tensions (Approximate)	*Blood pressure reactions*
Record I	36	Increased from 104 to 140 and 122 to 158.
Record II	43	Increased from 94 to 120 and 100 to 132.
Record III	44	Increased from 70 to 86 and 70 to 94.
Record IV	48	Increased from 55 to 60 and 54 to 65.
Record V	36	Increased from 72 to 80 and 70 to 92.

Note that besides a depression of the pressor vascular reflex by the increased tensions of ether there is an increased response to the reflex inhibition of respiration.

not always decrease the blood pressure. However, there was always a marked decrease in the pressure when tensions of 48 or 50 were reached.

Not only is the blood pressure not depressed to any great extent by the lower tensions, 36 to 45, but it quickly recovers even after the animal has been etherized for many hours. This is not true for the higher tensions. After an animal has been under a tension between 48 and 55 for an hour or two, blood pressure is greatly depressed

PRESSOR AND DEPRESSOR RESPONSES.

FOR THE PURPOSE OF this study the vascular reflexes may be divided into four groups. The first division is that of pressor and depressor. Stimulation of any mixed nerves will produce these reflexes. When the stimulus is relatively strong and the rate rapid, pressor responses are elicited. When the stimulus is weak and the rate slow depressor reflexes are produced. Each of these reflexes may be divided into two groups, depending upon their path. In a mixed cerebral nerve the number of neurones between the one stiumuated and the vasomotor center must be few. In all the other nerves at least for pressor reflexes there are a large number of intermediary neurones. The vagus was taken as the example of a nerve with few intermediary neurones while the sciatic was taken as representative of those having many intermediary neurones. In each instance the nerve was sectioned and the central end stimulated, care being take to stimulate in the same manner each time.

The pressor vascular reflex produced by stimulation of the central end of the vagus is the easiest of the vascular reflexes to obtain in the dog and for that reason it was studied the most extensively. This reflex is greatest at tensions between 36 and 45. In most instances it is decreased under tensions above 45 although a well-marked rise usually occurs under all tensions up to 48. It is either gone or barely perceptible at a tension of 50 and rarely persists at all above this tension.

Like the blood pressure, it is quite common for the reflex to progressively decrease under each increase of tension until it finally disappears. But this is not constant and in several experiments the reflex might be slightly greater at the higher tension. However, the range of tensions under which it is well marked and the limits at which it disappears are very constant.

The character of the reflex also changes with the change of ether tension. Under the lower tension the rise is not only greater but it is sustained for a greater length of time or a depressor effect takes place immediately after stimulating. As the animal becomes more deeply etherized under the higher tensions the blood pressure does not increase so much but quickly returns to its former level upon cessation of the stimulus. After an animal has been under the higher tensions for some time and the anesthetic is then withdrawn until the anesthesia becomes very light, the vascular reflex is usually well marked but not so great as it was initially under a tension of 36.

The pressor vascular reflex produced by stimulation of the central end of the sciatic is depressed by all tensions above 45 and does not appear to persist at tensions above 50. In this respect it is very similar to that of the vagus except that it is more greatly depressed by increased tensions and probably disappears sooner.

Depressor reflexes of either the vagus or the sciatic are quite difficult to obtain in the dog. For this reason the deduction of definite conclusions in regard to the depressor reflex should not be made until comparative data are obtained also in the cat and rabbit in which animals these reflexes are easily elicited. However, in the experiments on the dog in which I was able to obtain depressor reflexes they appeared to parallel quite closely the pressor reflexes in the same nerves under the same ether tension although they sometimes disappeared under a lower tension than the pressor reflex. This was shown best by the depressor reflex produced by stimulating the central end of the vagus.

Blood pressure always persists at either a high tension or for a longer period of time under the same tension than the respiration. The respiration usually fails at a slightly lower tension than the vascular reflexes although in some cases this reflex fails first.

CONCLUSIONS.

THESE CONCLUSIONS dealing with the vascular changes under different tensions are based upon experiments performed upon the dog, the Connell apparatus being employed.

1. In general, the physiologic phenomena due to ether are remarkably constant at the same tension in different dogs.

2. The lowest ether tension which will allow operative work is 36.

3. Any tension between 36 and 45 is safe as regards the life of the animal.

4. Any tension between 48 and 60 is liable to prove fatal.

5. Probably no individual dog can survive a tension of 60.

6. The corneal reflex does not persist at tensions above 45.

7. Blood pressure may remain practically the

same or be successively slightly decreased at each increase of tension up to 48. It is always greatly decreased by tensions at or above 50. It reaches zero under tensions between 50 and 60.

8. The pressor vascular reflex produced by stimulation of the central end of the vagus is greatest at tensions between 36 and 45. It is decreased under tensions above 45 although a well-marked rise usually occurs under all tensions up to 48. It is either absent or only barely perceptible at a tension of 50 and rarely present at all above this tension.

9. The pressor vascular reflex produced by stimulation of the central end of the sciatic is depressed by all tensions above 45 and does not persist at tensions above 50.

10. The pressor reflex of the sciatic seems to be depressed more greatly by increased tension than that of the vagus.

11. In the instances in which it was possible to study the depressor reflex it appeared to parallel quite closely the pressor reflex in the same nerve under the same tension although it did not persist under quite as high tensions.

12. Respiration usually ceases under a slightly lower tension than the pressor vascular reflex of the vagus disappears although either one may fail slightly before the other.

Editor's Note.—Just before his death the late lamented F. M. Nagle of Montreal, first Canadian President of the American Association of Anesthetists, began some clinical observations on the effects of various tensions of ether vapor in the use of the Anesthetometer for routine anesthesia in various surgical clinics. Nagle in discussing Mann's paper corroborated his findings and considered Mann's conclusions about optimum tensions as applicable in every day anesthesia practice. It remains for some anesthetists to continue the observations begun by Nagle and report definitely on the results.

MANY DISPUTED POINTS regarding shock and exhaustion remain so vexing that Walden E. Muns, of Columbia, Missouri, used the facilities of the Laboratory of Physiology of the University of Missouri, in an attempt to arrive at some definite conclusions regarding the effects of ether anesthesia and of visceral trauma as shown by vasomotor and blood pressure changes. In presenting his observations before the American Association of Anesthetists, during the Fifth Annual Meeting in New York City, June 2, 1917, Muns emphasizes the surgical lesson that is to be learned from his experiments.

These experiments, which have been reported elsewhere[1] were undertaken with a view of determining the actual circulatory changes taking place in the organism during long continued third stage ether anesthesia without other procedures, and also during maintained visceral irritation in the abdomen, the subject being under ether anesthesia.

POINTS UNDER DISCUSSION.

THERE ARE MANY vexing and moot questions that come up in the consideration of circulatory changes during ether anesthesia. Investigators agree generally that in ether anesthesia there is first a rise in blood pressure corresponding to the first or excitment stage of anesthesia which is followed by a distinct lowering of pressure in long continued third stage anesthesia. Indeed it is a fundamental property of anesthetic substances that they produce the phenomena of excitation before that of depression. Concerning the causes of lowered blood pressure in third stage anesthesia writers do not agree. There are

1. Proc. Soc. Exper. Biol. & Med., 1915, Vol. xii, 87-90. Journal Missouri State Medical Association, 1915, Vol. xii, 482; and Annals of Surgery December, 1916.

those who maintain that local action of ether on the heart is responsible for the hypostasis, while others see in the phenomena a central as well as a local vasomotor effect.

The condition of the peripheral arteries during third stage ether anesthesia also provokes disagreement. While most all writers agree that the smaller arteries and capillaries are dilated, the opinions diverge on the cause of the action. Some claim a central medullary depression with peripheral paralysis, while others see a direct local dilatation.

Visceral irritation such as experimental intestinal trauma or ordinary surgical operations under ether anesthesia is accompanied by certain circulatory changes. All workers, of course, agree on the pure observable phenomena. While a low blood pressure in shock is a common observation, the theories as to its cause are quite divergent and have caused a great deal of discussion. Against those who proclaim exhaustion and paralysis of the vasomotor center as the cause are those who maintain that other factors are at work.

Inseparable from the subject of blood pressure in shock, is the question of the condition of the peripheral arteries. The greatest disagreement exists between observers as to whether the smaller arteries and arterioles are dilated or contracted in shock. Whether they are contracted or dilated there seems at present to be no chance of agreement as to the reasons for either phenomenon.

While it is impossible to answer all of these questions by deductions from a relatively few graphic experiments, it may be possible to at least set at rest a few doubts as to the purely observable phenomena in connection with the circulatory system.

METHOD OF EXPERIMENTATION AND RESPECTIVE RESULTS.

IT IS PROPOSED therefore to graphically demonstrate the actual changes in the blood pressure, and in the vasomotor reactions during ether anesthesia, and those variations accompanying visceral trauma under ether. Such experiments may show the definite relations existing between the blood pressure and the vasomotor status, and also the relationship between the depression and the mechanical stimulation of the visceral manipulations. The question naturally arises as to what depressing, exciting, or neutralizing effect the anesthetic may have on the vasomotor mechanism in surgical manipulation of viscera.

Dogs weighing 6 kg. to 12 kg. were used. The ether was administered by intratracheal tube through an ordinary breathing bottle in half the cases, and by continuous insufflation in the other half. The blood pressure was taken from the carotid and recorded through a mercury manometer. One hind leg of the dog was placed in a plethysmograph of large size; the apparatus was then connected with a recording water manometer and the whole system filled with water. Every change in volume of the leg denoted a variation of the peripheral vasomotor mechanism within the leg.

In one series of experiments many dogs were caused to remain under ether for long periods of time, records being graphed every half hour. The shortest experiment was one hour in length and several experiments lasted six hours and over. In several cases there was a slight fall of blood pressure after the first half hour. In one-half of these cases the fall in pressure continued to death, and in the other half there was a slight gradual rise to death. In those cases showing rapid fall of blood pressure, the animals died in a short time. The dogs that showed a gradual rise of pressure remained alive six hours and over. In five to forty minutes after the beginning of the experiment, a change in leg volume was noted. Several cases showed a vasodilatation and several showed a vasoconstriction. At the end of the first half hour there was a general vasodilatation shown in all cases but one. At the end of the first hour (the second hour of anesthesia), all cases showed a marked vasodilatation, which condition slowly increased, with occasional periods of vasomotor recovery, until at death there was a total increase of leg volume of 2 cc. to 18 cc.

The normal tone and resistance in the arteries were altogether or partly destroyed in all cases, and the blood pressure lowering effect of this one factor, obtaining throughout all the periphery, must have been tremendous. Why, then, was there in half the cases a decided and fatal fall in blood pressure, and in the other half a decided maintenance of the tension? It is evident that the question must be answered by considering the normal compensatory reaction of the heart to the blood pressure lowering tendency of the peripheral dilatation. While the heart did not increase in rate in any instance, there was a decided increase of ventricular output, an increase great enough to overcome the hypostatic effect of the peripheral dilation: the blood pressure was maintained and even raised a little. It is evident that if the heart fails to show this compensatory reaction, because of organic disease, or too early response of the nervous center to the effect of the anesthetic, the blood pressure must fall, as it did in the three cases noted.

In summing up the results of these anesthesias the circulation, it is permissible to argue that any means of preventing or overcoming the peripheral vasodilatation would have helped to maintain the blood pressure.

In summing up the results of these anesthetics we may say that (1) ordinary third stage ether anesthesia prolonged beyond one hour results in marked vasodilatation of peripheral vessels; (2) that there is a direct relationship between the condition of the vasomotor control and the blood pressure; and (3) that the end result of ether depression is loss of vasomotor function and death.

EFFECTS OF TRAUMA.

IN ANOTHER SERIES of experiments the dogs were anesthetized after which the whole small intestine was delivered through an incision in the linea alba. The intestine was then kneaded and rolled between the hands or in a towel constantly for varying lengths of time, deep anesthesia being maintained. The experiments lasted from 45 minutes to 165 minutes after adjustment of the apparatus. The deep anesthesia and the violent trauma brought on death quickly. In all cases but two the blood pressure was maintained throughout the experiment, or at the end was higher than at the beginning. It was only at the very last minute of life that the loss of vasomotor function occurred and the blood pressure fell rapidly to death. In all cases but one, there was a definite vasoconstriction of peripheral arteries which resulted in a fall of leg volume of 2 cc. to 10 cc. This change in the peripheral vessels began almost immediately, the intestines were disturbed and continued as long as the stimulation was applied.

The vasoconstriction in the peripheral vessels seemed to be an important factor in maintaining the blood pressure in cases of gradually developing collapse from ether depression, as it may be in cases of lowered blood pressure from splanchnic dilatation in traumatic shock. Whenever the intestinal irritation was not accompanied by vasoconstriction of the peripheral vessels, the blood pressure tended towards a fall, through the vasomotor depressant effect of the ether. Whenever the vasoconstriction was present *but slightly*, the blood pressure showed itself to be better maintained, the depressor and pressor agents offsetting each other. When the vasoconstriction was marked, the tendency towards the maintenance of the general blood pressure was greater. In some cases there was an actual rise of blood pressure due to the domination of the pressor over the depressor effect.

In summing up the results of these intestinal trauma experiments we may say that (1) manipulation of the intestines brings about a vasoconstriction; (2) that there is a relationship between this vasoconstriction and the blood pressure.

RELATION OF STIMULATION AND EXHAUSTION.

IN THE LIGHT of what we have learned from these and other experiments, it may be said that an anesthetic substance such as ether and an irritation to abdominal viscera such as intestinal handling, produce two different kinds of stimuli. The anesthetic substance first excites and then depresses. The depression is its essential and marked effect and if too prolonged it results in total functional incapacity. The effect of visceral irritation is wholly excitatory, being mechanical. When this irritation becomes too severe or is continued too long the summated excitant stimuli lead to over-activity and fatigue, and the end of fatigue is exhaustion. Then both the anesthetic and the visceral injuries may lead to absolute conditions, either complete depression or complete exhaustion. But, though the end result is reached by entirely different processes, the effect is identical in a complete functional incapacity. An exhausted function is just as incapacitated as a depressed function

In the ordinary major operation with ether as the anesthetic, a moderate amount of excitation from handling is a helpful factor. There can be no question that there are occasions, when the patient is on the verge of syncope from ether depression, when a vigorous cutaneous or visceral irritation would restore the vasomotor tonus, resulting in a beneficial reflex rise in pressure. There are many experiments that show the sensitiveness of the vasomotor mechanism to reflex stimulation, and it is clear how such a reflex stimulation in proper time and moderation may very well become a remedial measure in impending ether death. There are a few reported cases where the sudden cessation of manipulation of the peritoneum during laparotomies resulted in arrest of heart and respiration. In such cases a certain amount of irritation was balancing a certain amount of anesthesia, and when the irritation was suddenly removed, the anesthesia slid into the danger phase. When sensory stimuli and the anesthetic are exhibited together there is one period when the excitation from the surgical technic and the depression from the drug are pitted against each other to the good of the patient. Either may be better borne in the presence of the other.

SURGICAL APPLICATION.

IF THE ANESTHETIC and its neutralizing irritation be continued too long or are of undue severity, the two antagonists become allies in effect and bring about a much quicker collapse from functional incapacity than had only one agent been at work. It is suggested therefore, that the symptom complex known as postoperative shock is a combination of the effects of excitation and depression and varies directly with these two factors.

If these deductions form the true explanation of the relationship and sequence of events in ordinary surgical operation that go on to postoperative shock, the present day ideas of prevention and treatment of such conditions must be altered. If one can accept the fact that ether anesthesia and visceral trauma may each in itself cause functional incapacity,[2] and that when applied together they may act quicker and surer than when used alone, there can be no crimination as of surgeon against anesthetist, or as of anesthetist against surgeon in case of accidents. If the prevention of postoperative shock depends upon a proper balance between the two types of stimuli, then both surgeon and anesthetist should quite properly understand such relationship, and so govern the administration of the two types of stimuli that they will not be too severe, too long continued, or too out of balance. The importance of this idea is being more and more recognized.

If functional incapacity may be brought about through the excessive application of either type of stimulus, or still easier by the use of both types together, the treatment of postoperative shock must be based on the proper designation of the predominating etiological factor. It is obvious that remedial measures designed to counteract a condition brought on by too much ether might not be exactly suited to cure traumatic or sensory shock. Although both conditions are expressed outwardly in the one common way the body mechanism can display them, the absolute condition is reached by entirely different processes.

2. Dolley, D. H.: The Cytologic Analysis of Shock. Jour. Medical Research, 1916, Vol. xxxiv.

BLOOD PRESSURE AS A GUIDE DURING MAJOR OPERATIONS . PLAN OF STUDY . SHOCK . ASPHYXIA . CEREBRAL ANEMIA . CONCLUSIONS . BLOOD PRESSURE OBSERVATIONS IN SURGICAL SHOCK AND THEIR IMPORTANCE . CLASSIFICATION OF RISKS . CASES STUDIED IN THIS PAPER . MOOTS' AND McKESSON'S RULES ON RESISTANCE AND SHOCK . CONCLUSIONS.

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REPORTING HIS STUDIES to the Surgical Staff of the Massachusetts General Hospital, and also to the American Association of Anesthetists, during its Sixth Annual Meeting, at Chicago, June 9-11, 1918, and publishing his results in the Interstate Medical Journal, Volume xxiv, No. 1, Harold G. Giddings, of Boston, Massachusetts, made a striking plea for the value of blood pressure as a guide during major operations.

It is a well-recognized surgical principle that whatever measures may be taken to safeguard the patient before, during, and after operation, should be used. In a previous communication[1] we have pointed out the necessity for most careful study of our patients' vitality and physical idiosyncrasies before bringing them to the table, as well as the need of painstaking watchfulness throughout their convalescence. But while these measures are most highly desirable, and to neglect them is inexcusable, we should go still further, especially in capital surgical procedures, and keep ourselves informed throughout the operation as to the exact condition of the patient. Such information it is perfectly easy to obtain through frequent readings of the blood pressure. These may be taken by the etherizer without in any way interfering with his other work, and the intelligence which he from time to time imparts is of great value to the operator. When all is going well, it is a distinct comfort to know it, and, on the contrary, if the patient's condition begins to decline, the operator is forewarned of impending disaster, and may take proper steps to combat it.

With a view to determining the value of blood pressure as an index during operations, we have studied a series of 50 cases, deliberately selecting operations of the distinctly major type, with enough simple ones to act as controls. The extensive pelvic dissections incidental to the radical Wertheim operation for cancer of the uterus, and the trying operations, in and about the mouth and neck for the same disease as performed by Dr. Farrar Cobb at the Massachusetts General Hospital, offered unusual and extreme opportunity for our study. Such operations, of course, place a tremendous tax on a patient's vital forces, and whatever changes may take place in major work are most likely to appear in this class of cases.

PLAN OF STUDY.

FOR COMPARISON WITH each patient's pressure during operation, we noted his pressure at the time of entrance to the hospital, taken as a matter of routine in the physical examination. With this as a starting point, the procedure was as follows: The systolic pressure and the pulse rate were noted when the patient reached the etherizing room and before anesthe-

1. GIDDINGS: Postoperative Treatment. Boston Med. and Surg. Jour., June 8, 1916.

sia was started, again at the time it was started, and at least once every five minutes throughout the operation. In many instances, or whenever there was taking place an obvious change in the readings, we recorded that change as often as once in two or three minutes. In addition, there was noted the time the operation was started, any change in the patient's position on the table, any specific steps, such as ligation of important vessels, anything likely to produce sudden reaction, or any event of special interest.

A Tycos sphygmomanometer was employed, and in the abdominal operations the patient's arm was carried above the head; in operations about the head and neck, where the arm lay at the side, the length of the tubing running from the cuff was increased by using glass connecting tubes between this tubing and other pieces of similar diameter about a foot long. In this way it was easy to get the pressure at all times without interfering with the operator.

In making these observations there are several opportunities for error, which must be guarded against. First, it is essential that the measurement be taken at the same level as the heart, for if made at a point lower than the heart we obtain not only the blood pressure, but the weight of the column of blood representing the difference between the level of the heart and the level of the observation, and, bearing in mind that a column of blood 10 cm. high gives a reading of 8:5 mm., the necessity for care is obvious; and conversely, if the point of reading be above the heart, a corresponding error in the negative direction occurs, so that we do not get the full pressure value.[2] Second, the cuff sometimes slips on the arm, even to below the elbow. It must be firmly adjusted; otherwise the reading may be from 20 to 30 mm. too high. Third, the air may be partially or completely shut off, either by a kink in the tubing or by the operator leaning against it, both easily overlooked, since the tubing is covered by the sheet. Fourth, the radial artery should not be on a stretch by extension of the hand, as thus the pulse beat is more quickly obliterated. Flexion of the wrist, as we observe it, gives between 5 and 10 more degrees in the reading. Fifth, it is always well to allow 10 degrees of pressure as the limit of error, as constant compression of the patient's pulse may cause vasomotor paralysis in the recorder's finger tips.

In no instance was the difference in the "individual levels"—the term we have applied to the patient's normal waking rate—as taken when the patients entered the hospital and when they reached the etherizing room, great enough to be seriously regarded. Their readings were, as a rule, slightly greater when they came to the operating floor than at the time of the intial physical examination. This was due, no doubt, to fear or excitement.

As a general rule, immediately after the start of anesthesia there is a rise of from 10 to 30 degrees in the pressure, but after a few minutes it again falls to somewhere near the patient's "individual level." This phenomenon is seen in both ether and in nitrous oxid anesthesia, and it appeared also in four cases anesthetized by rectal anesthesia. The rise is due, undoubtedly, to the sudden introduction into the blood of a foreign gas, which instantly acts upon the vasomotor center in the medulla, raising the pressure. The "individual level," after being reached, is maintained rather closely throughout anesthesia. barring changes due to oncoming shock, asphyxia, sudden cerebral anemia, or changes in the patient's position on the table. Certain other factors, such as struggling, depth of anesthesia, and manipulation of organs, also influence the pressure, but to a less degree. (Charts I, II.)

SHOCK.

IN SEVERAL CASES of shock of varying degree, there was, as a rule, a gradual fall in the pressure, as shown by the readings, starting from twenty to thirty minutes before there appeared an appreciable rise in the pulse rate. This fall was too slight to detect without a recording apparatus, but was gradual in the succeeding readings, showing a progressive fall of from 5 to 10 degrees. This made it possible to

2. Janeway: The Clinical Study of Blood Pressure, pp. 37, 38.

notify the operator of the patient's failing condition a considerable time before there was notice-

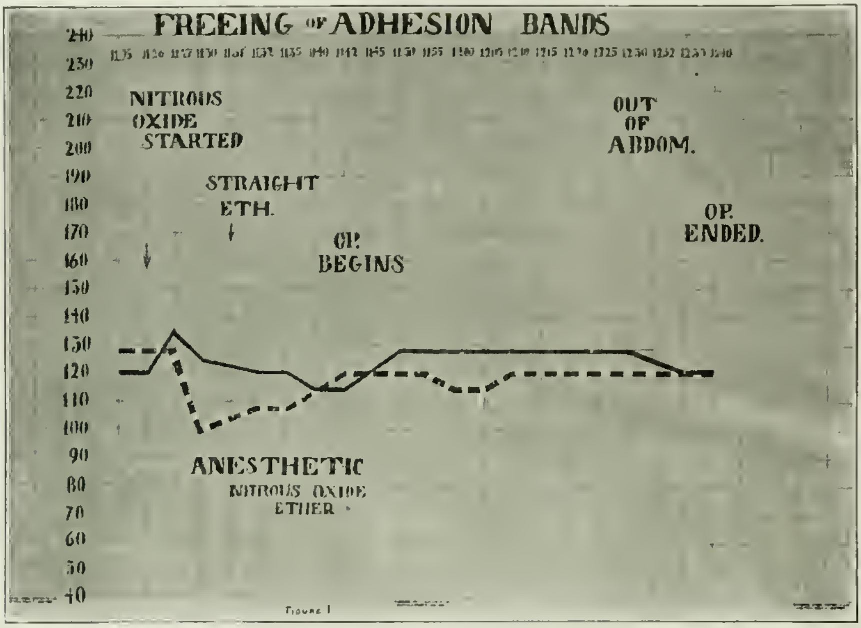

Chart I.—Note initial rise of blood pressure almost synchronous with beginning of nitrous oxid, which soon fell again to the "individual level," remaining there throughout the operation. This chart is characteristic of the controls.

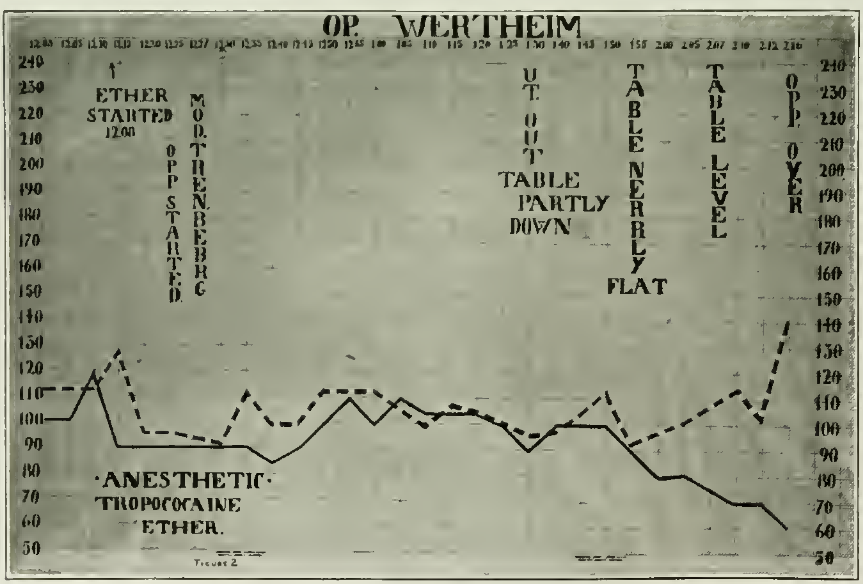

Chart II.—Illustrating the drop in pressure to a point below the "individual level" after the initial anesthetic rise. This phenomenon, followed by the rebound to the patient's level, is nearly constant.

able change in the quality or rate of the pulse, signs on which it is ordinarily the custom to depend for warning of imminent failure or shock; and by acting early in these cases, conditions which easily might have become serious were rendered harmless. The rule that the pressure falls first does not, however, invariably hold true, for in some instances the beginning drop in pressure and the rise in pulse rate were virtually simultaneous. (Charts III, IV, V, VI.)

ASPHYXIA.

JANEWAY HAS POINTED out that in first-stage asphyxia, during which the respiratory center is stimulated and the breathing is

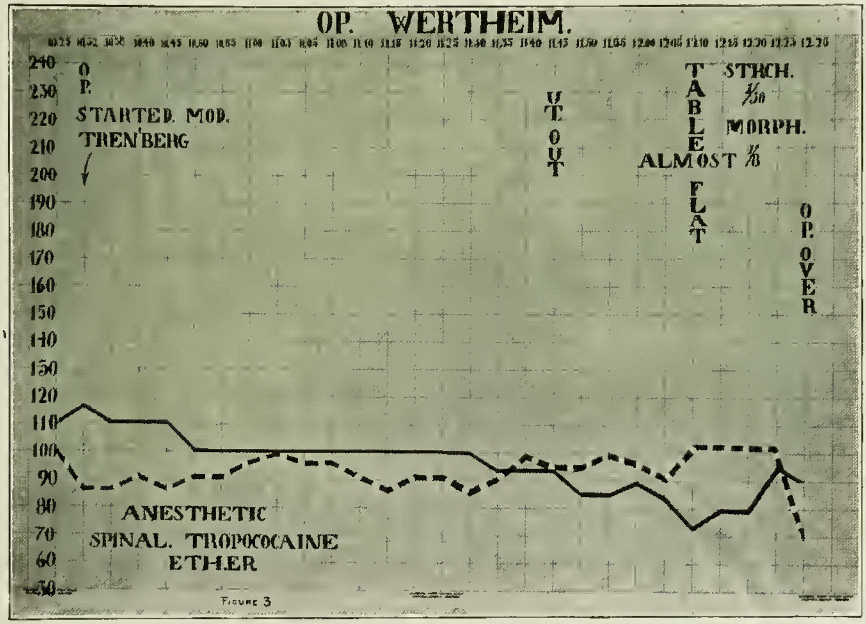

Chart III.—In this case, at 11:30 a. m., an hour after the operation had been started, there began a gradual fall of pressure, indicative of failure. The alteration was unaccompanied by appreciable change in the pulse rate. The upward rise at 12:10 p. m. was in all probability due to the fact that no more traumatizing work was going on in the pelvis.

Chart IV.—Moderate shock, with gradual fall in pressure and rise in pulse rate. Observe that the pressure fall began from a quarter to half an hour before the pulse rate appreciably increased. The sudden drop at 12:25 p. m. was very likely due to the increased Trendelenburg position and to the muscular straining.

rapid and deep, the vasomotor center in the medulla is also thrown into action, and a marked rise in the blood pressure occurs. This is also seen in slighter grades of deficient oxygenation

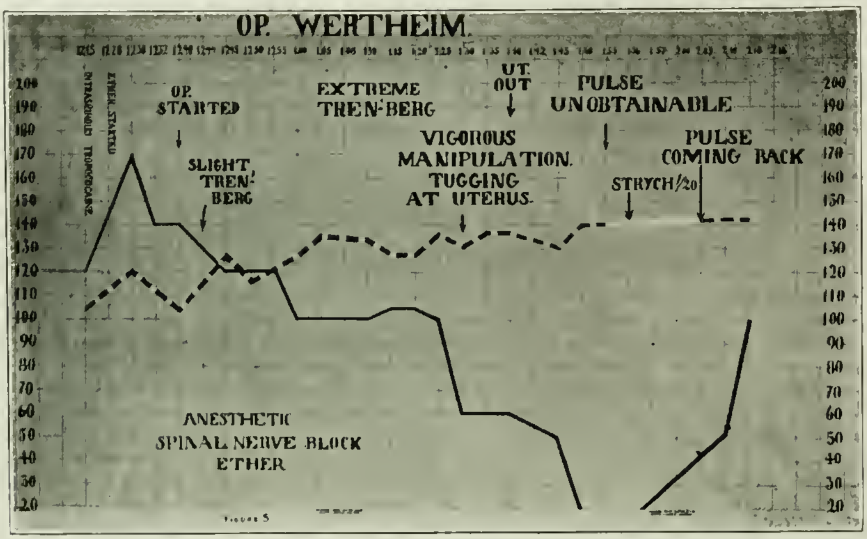

Chart V.—Typical chart of shock, in which the fall in pressure and rise in rate were practically simultaneous. The sudden drop at 1:30 p. m. is illustrative of what manipulation of the pelvic and abdominal organs may produce in pressure changes.

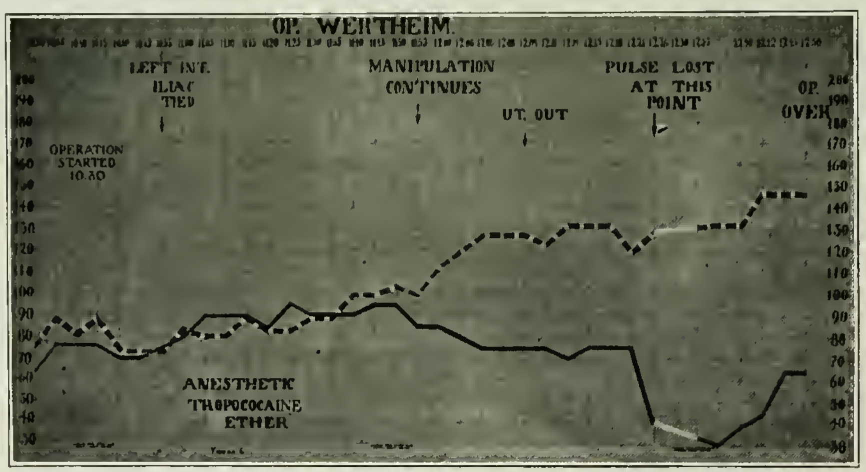

Chart VI.—Characteristic shock chart. An initial fall, as illustrated here, following the intraspinal injection of tropacocain, was not uncommon. During the first hour the pressure rose from a low point at the start to a higher level. From 11:30 to 11:50 a. m. the operator was freeing the parametrium from pelvic walls, the procedure requiring a good deal of manipulation. This undoubtedly was what induced the shock. This patient responded very quickly to stimulation after being put to bed.

of the blood. Janeway applies this observation more especially to the study of cardiac and lung conditions and to laryngeal diphtheria.[3]

This phenomenon occurred in two cases of the series, both in operations about the face. In each instance it was possible to warn the operator, even before there had taken place the usual darkening of the blood, that the patient was getting an insufficient supply of air. As the difficulty in these cases is usually due to the operative procedures, rather than to the anesthetic, the warning to the surgeon is of real value. Chart

3. Janeway: The Clinical Study of Blood Pressure, p. 59.

VII vividly represents the pressure change which comes with interference in breathing.

IN CEREBRAL ANEMIA the pressure phenomenon is exactly the reverse of what is seen in asphyxia. In each of the three operations in which it was observed—all of them for cancer about the mouth—the patients were, at the time of the occurrence, in the reversed Tren-

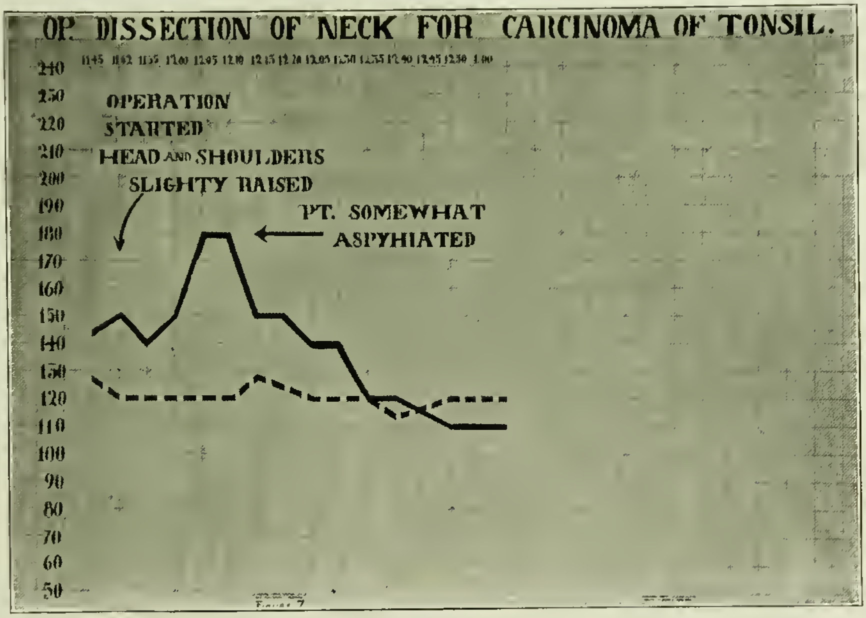

Chart VII.—At 12:00 m. the first upward rise was noted. During the next five minutes it went from 150 to 180. At this point the interference with respiration was eliminated and the pressure immediately dropped. The continued fall was probably a forerunner of shock.

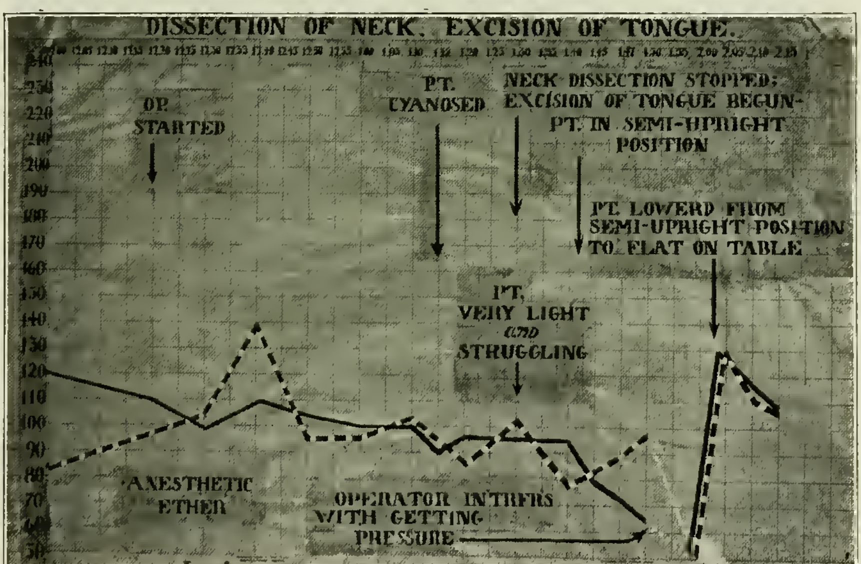

Chart VIII.—Phenomenon of cerebral anemia. Note the instant drop in pressure at 1:40 p. m. when patient was put in semiupright position; also the continued and rapid fall in both pressure and pulse until table was again in a horizontal plane. Then observe the instant rebound to point above the "individual level" and immediate subsidence toward subanesthetic line.

delenburg position. The fall in pressure was invariably almost instant, very alarming, and accompanied by marked slowing of the pulse. Immediately on change of position to the level, or slight Trendelenburg, the pulse and pressure righted themselves with a bound, going at first

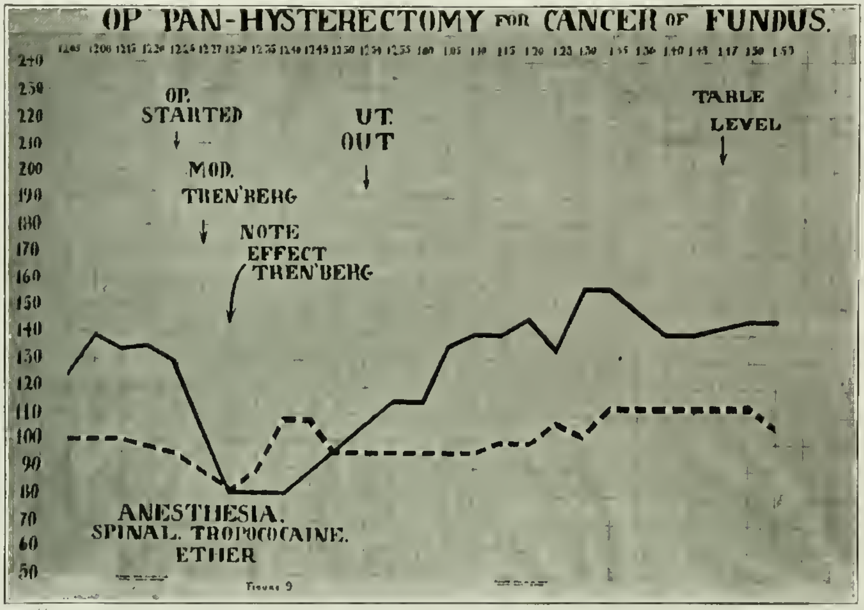

Chart IX—Effect of Trendelenburg position (see also Charts II, IV, V, X. Chart II illustrates that occasionally there may be no change whatever). In all these cases of Trendelenburg position it is not unlikely that the fall may have been due to manipulation of the pelvic viscera, or possibly to the gravitation of the tropacocain to the higher nerve centers.

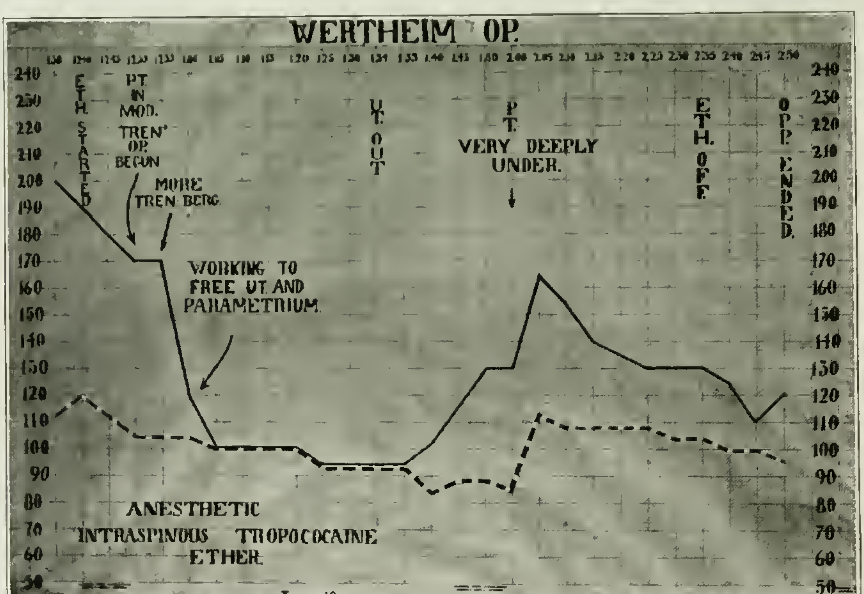

Chart X.—Illustrates very graphically the combined effect of Trendelenburg position and manipulation of the pelvic organs. The latter was undoubtedly the principal factor in this instance, for the drop came almost immediately after the operator began his work in the pelvis. Observe the rise which appeared as soon as the uterus was removed.

to an excess of the rate they had maintained up to this time, then quickly subsiding to the normal subanesthetic point for the individual. (Chart VIII.)

TRENDELENBURG POSITION.

IT HAS BEEN SAID that the effect of the Trendelenburg position is unfavorable to patients, and, with a view definitely to determine whether this was so, we carefully observed the result of placing individuals in this unnatural posture. In nearly every instance there was an almost immediate fall in pressure, to a greater or lesser degree, though, as a rule, the downward curve was not an alarming one, and the pressure soon returned to the "individual level." Nor did keeping patients in this position over considerable lengths of time apparently produce untoward results. (Charts IX, X.)

CONCLUSIONS.

THE BLOOD PRESSURE index is a valuable guide in major surgical work. It is of special value in operations likely to be of long duration, in which the element of shock is apt to appear; also in operations upon delicate women, weak men, or obviously poor risks. In great operations about the head or neck it is of very definite worth frequently giving warning as nothing else could, of approaching asphyxia or cerebral anemia. In the class of cases studied it adds to the operator's sense of security and to the patient's safety. We do not, however, advocate it as a routine measure.

We take this opportunity to thank Dr. Cobb for the privilege of studying his cases and the staff of the Massachusetts General Hospital for permission to report the results of the study.

SURGICAL PROGNOSIS should be better than it is. Albert H. Miller, of Providence, R. I., brought this matter to the attention of the Academy of Medicine of Boston, late in 1918, and his illuminating findings on the importance of blood pressure observations in surgical prognosis were published in the Boston Medical and Surgical Journal, Volume clxxx, No. 1, and were made the subject of editorial review in the Anesthesia Supplement of the American Journal of Surgery, April, 1919. On account of their value, Miller's studies from a thousand cases are given in detail.

In the present advanced state of surgical knowledge, Miller contends, the patient has a right to expect a fairly exact preoperative diagnosis and a very exact preoperative prognosis. The prognosis is a matter of importance to the surgeon as well as to the patient. Skill in prognosis results from experience and can be gained in no other way. The surgeon who makes and records a prognosis before each operation and checks up his preoperative opinion with the result will rapidly gain in skill in this important department.

For making a preoperative prognosis and for judging the condition of the patient during operation, the blood pressure is the most valuable single means at our disposal. It may uncover arterio-sclerosis, nephritis, myocarditis, aortic insufficiency, or mitral stenosis. It registers the patient's ability to withstand hemorrhage, the depression of the anesthetic, and surgical shock. During the operation, the blood pressure provides the most valuable key to the patient's condition and gives early warning of the presence of shock.

CLASSIFICATION OF CASES.

THE PATIENT WHO has undergone a proper physical examination before operation will be listed in one of three classes:

The *good* risks: Patients free from organic disease, whose surgical condition is not likely to prove fatal.

The *fair* risks: Patients suffering from organic disease but whose surgical condition is not specially serious.

The *poor* risks: Patients whose surgical condition is so serious or so far advanced as likely to result in fatality.

All patients of the first class are expected to recover. If a fatality should occur among this class of patients, the case should be carefully gone over to determine whether the preoperative prognosis was in error or if the work of the surgical team is blamable for the fatality.

As an example of cases of the second class; an operation for appendicitis might be urgently required in the case of a patient whom the examination showed to be affected with diabetes. If coma and death follow such an operation, the fatality will be considered to have resulted from conditions beyond human control. If no examination and no prognosis had been made, the necessity for a lame explanation of the result would have arisen.

In the third class are those patients so desperately ill that recovery without operation is unlikely.

CASES STUDIED IN THIS PAPER.

IN A SERIES OF 1,000 consecutive operations in which the classification was employed, the results were as follows:

Risk	Good	Fair	Poor	Total
Cases	734	179	87	1,000
Deaths	2	14	29	45
Percentage	.27	7.82	33.33	4.5

These deaths occurred from twenty-four hours to three weeks after the operation. No death took place during or immediately following the operation. Measured methods of anesthesia were used exclusively.

MOOTS' RULE.

C. W. MOOTS, of Toledo, O., has formulated a rule for determining the resistance of patients by preoperative blood pressure tests. He states the rule as follows: "A case has a systolic pressure of 120 and a diastolic pressure of 80; the pulse pressure is 40 and the ratio of pulse pressure to diastolic is 40 to 80 or one-half, which means 50 per cent. of the diastolic pressure. This pressure ratio is really an important matter, as it represents the relationship existing between the kinetic energy expended by the cardiac contraction in moving the blood column and the potential energy stored in the arterial walls and column of blood which they contain. *If the pressure ratio is high or low, there is reason to apprehend danger. If the pressure ratio lies between 25 per cent. and 75 per cent., the case is probably operable; if outside these limits, it is probably inoperable.*"

To determine the accuracy of this rule, the series of 1,000 cases referred to has been checked up with the rule in mind. Of the operable cases, according to Moots' rule, 3.23 per cent. died and 96.77 per cent. recovered. Of the inoperable cases, 23.07 per cent. died and 76.93 per cent. recovered. Some of the cases classed as inoperable underwent minor operations safely, and some of those classed as operable died after very serious operations and under circumstances which could not have been readily predicted. The result shows the great value of Moots' rule in surgical prognosis.

MCKESSON'S RULE.

E. I. McKESSON, of Toledo, O., has formulated a rule for measuring the severity of shock during operation. He holds that "a typical case of shock is characterized by a diastolic pressure of 80 millimeters or less, a pulse pressure of 20 or less, and a pulse rate of 120 or more," and states that "*after a half hour of sustained low pressure and rapid pulse has been passed, almost every patient succumbs either* *shortly or within three days of surgical shock and heart exhaustion.*"

The series of 1,000 cases referred to has also been checked up to determine the value of this rule. In a considerable number of cases, shock has appeared as determined by McKesson's rule, has been reported to the surgeon, and the operation has been rapidly completed. All of these patients have recovered. Thirteen of the patients were in the danger zone as determined by this rule for from 25 to 70 minutes. Of these, nine died, giving a mortality rate of 69.23 per cent. These figures indicate the efficiency and great value of McKesson's rule for determining shock during operation.

CONCLUSION.

EVERY OPERATIVE CASE deserves a preliminary examination, diagnosis, and prognosis. The blood pressure examination is distinctly valuable in making the preliminary prognosis and in the diagnosis of surgical shock. The rule of Moots for determining the resistance of the patient and the rule of McKesson for diagnosing surgical shock are trustworthy and valuable aids.

TO MAKE A GOOD ANESTHETIST CERTAIN QUALITIES, MENTAL AND PHYSICAL, ARE DESIRABLE, SOME INDEED ARE ESSENTIAL, AND ANYONE LACKING THEM WOULD BE ILL-ADVISED TO EMBARK ON THE CAREER. THE ANESTHETIST NEEDS A WELL-BALANCED MIND CAPABLE OF FORMING JUDGMENTS RAPIDLY. IN ORDER TO FORM THEM HIS POWERS OF OBSERVATION SHOULD BE GOOD AND HE SHOULD TRAIN THEM TO THE HIGHEST PITCH OF PERFECTION. AGAIN HE SHOULD NOT BE NERVOUS AND HASTY ON THE ONE HAND, NOR TOO SLOW AND PHLEGMATIC ON THE OTHER. METHOD AND ORDERLINESS ARE REQUIRED. HE SHOULD HAVE EVERYTHING SET TO HAND SO THAT EVEN IN A DARKENED ROOM IT CAN BE FOUND AT ONCE. HE SHOULD DO EVERYTHING WITH RAPID DELIBERATION AND COLD DESPATCH. IT IS BETTER TO DO NOTHING WELL THAN TO DO THE WRONG THING AND DO IT BADLY. IN GRAVE EMERGENCIES THE ANESTHETIST IS SOMETIMES EMBARRASSED BY WELL-MEANING HELPERS WHO LOSE THEIR HEADS. THE ANESTHETIST MUST ALWAYS KEEP COOL; IT IS UP TO HIM TO KNOW WHAT IS THE RIGHT THING TO DO AND THE BEST AND QUICKEST WAY OF DOING IT. THE BEGINNER SHOULD NOT BE COCKSURE BUT SHOULD RATHER RECOGNIZE HIS OWN LIMITATIONS AND FALLIBILITY AND BE READY TO ACCEPT ADVICE FROM THE MORE EXPERIENCED. IN ADDITION THE ANESTHETIST SHOULD BE POSSESSED OF AN ALMOST INEXHAUSTIBLE PATIENCE; ESPECIALLY WHEN DEALING WITH DIFFICULT AND REFRACTORY SUBJECTS IN AN ATMOSPHERE CHARGED WITH IMPATIENCE.

—*G. A. H. Barton.*

A CLINICAL STUDY OF BLOOD PRESSURE, PULSE PRESSURE AND HEMOGLOBIN ESTIMATIONS IN POSTOPERATIVE SHOCK, HEMORRHAGE AND CARDIAC DILATATION . PULSE PRESSURE AS THE PREOPERATIVE INDEX OF CARDIAC STRENGTH . HEMOGLOBIN AND LEUKOCYTES . BLOOD COAGULATION TIME . NORMAL REACTIONS . SHOCK CONDITIONS . DIFFERENTIATION BETWEEN SHOCK AND HEMORRHAGE . CARDIAC DILATATION . RELATION OF PULSE PRESSURE AND KIDNEY FUNCTION TO OPERATIVE PROGNOSIS . CARDIAC FORCE . PHTHALEIN OUTPUT . RELATION OF PULSE PRESSURE AND KIDNEY FUNCTION . CONCLUSIONS DRAWN FROM THESE CLINICAL STUDIES .

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OCCASIONALLY THERE IS considerable difficulty in making the differential diagnosis between postoperative shock and concealed intra-abdominal hemorrhage. The clinical picture in many cases is so identical that even the most experienced may err unless proper recognition is given to the changes in the composition of the blood which take place in these two conditions, which may be shown in the hemoglobin percentage and red and white cell count, together with the comparative blood pressure readings. Speaking before the American Association of Obstetricians and Gynecologists, 1917.[1] and later before a Joint Meeting of the Interstate Association of Anesthetists and the Indiana State Medical Association, at Indianapolis, September 26, 1918, John Osborn Polak, of Brooklyn, N. Y., detailed the experimental and clinical work that had been done at the Long Island College Hospital to clear up this problem as well as to determine the relation of pulse pressure and kidney function to operative prognosis.[2]

During the past two years, at the Long Island College Hospital, we have been making a series of clinical observations upon the relation and clinical importance of blood pressure, pulse pressure, hemoglobin percentage, and leukocyte changes in postoperative shock and hemorrhage and in postoperative cardiac dilatation. The object of this study has been an attempt to correlate the value of laboratory findings as an aid in making a differential diagnosis in shock, hemorrhage, and cardiac dilatation, the bedside diagnosis of which, as I have said before, is often confusing or indeed even impossible.

A preliminary report of this work was offered before the section of Obstetrics and Gynecology of the New York Academy of Medicine in November, 1916, by my resident gynecologist, Dr. Otto H. Hefter. In this preliminary report the details of the procedure employed were carefully described. Our routine was as follows: Readings were taken on the day previous to operation. As soon as possible after operation a second reading was taken. Observations were repeated at convenient intervals for several days. Due to the fact that the work was carried on in conjunction with the routine ward work of the hospital it was impossible to establish a definite schedule as to the time of making observations. Usually the first reading came within one hour following the operation, and several subsequent readings were made within the first twenty-four hours.

1. Polak, J. O.: Transactions of the American Gynecological Society, 1917.
2. Polak, J. O.: American Journal of Surgery, Anesthesia Supplement, July, 1919.

Further readings came at daily intervals or from three to five days. The blood pressure readings were taken from the mercury column sphygmomanometer by the auscultatory method. The hemoglobin estimations were made with the Shali apparatus. The standard Leitz-Wetzler counting chamber and pipettes were used in making the blood counts. Blood smears were stained with Wright's polychrome solution.

Therefore we will not take up your time in describing these details anew, save to say that the pulse pressure was taken in the great majority of instances by the same man, and the reliability of the data can therefore be vouched for.

PULSE PRESSURE AS THE PREOPERATIVE INDEX OF CARDIAC STRENGTH.

FROM THIS STUDY we have found:

1. The *preoperative index of the woman's cardiac strength is the pulse pressure.* It makes no difference, so far as the operative prognosis is concerned, whether the systolic blood pressure is 105 or 160 mm. so long as the diastolic pressure is not within 30 mm. of the systolic. In other words, provided the metabolism is near the normal the pulse pressure of the individual is the index of cardiac strength no matter what her systolic blood pressure may be. The only exception to this statement is the very high pulse pressure in aortic regurgitation.

HEMOGLOBIN, LEUKOCYTE AND BLOOD COAGULATION TIME ESTIMATES.

2. The *hemoglobin and leukocyte count* are the next important factors for preoperative determination.

3. The *blood coagulation time of the individual is* of considerable significance as a preoperative consideration.

These observations, together with a knowledge of the efficiency of the kidneys, as shown by the usual functional tests, are made as a preoperative routine. Their routine employment will give the woman her greatest margin of safety, and afford the surgeon a basis for his differential diagnosis in postoperative conditions. With these factors definitely known it is an easy matter, in any given case, to follow the postoperative course for the first twenty-four or forty-eight hours, and by the further aid of the laboratory to be able to make a strong presumptive diagnosis as to the complicating postoperative condition.

NORMAL REACTIONS.

IN THIS STUDY we will consider what normally happens after an abdominal section with fifty to eighty minutes ether anesthesia. In this series of cases ether anesthesia, by the open or closed method, with preliminary morphin and atropin, was employed. The average length of anesthesia was seventy-five minutes. The average amount used was 5 ounces. It was found there was a *rise of from five to fifteen points in the hemoglobin reading as taken from peripheral blood in 80 per cent. of the cases studied*, which rise was directly proportionate to the length of anesthesia and the amount of anesthetic used. In 12 per cent. of the cases the hemoglobin reading remained unchanged. In one-half of these cases, however, the length of the narcosis was considerably below the average for the series. The remaining 8 per cent. showed a drop in the reading. These were cases of hysterectomy in which there was considerable blood loss. Four cases remained unchanged with no apparent explanation. In endeavoring to account for the rise in hemoglobin, erythrocyte counts were taken with the readings. These remained fairly constant, with only a variation ranging from 100,000 to 200,000 cells, which, we feel, is within the range of error. It was found that in from six to forty-eight hours the hemoglobin reading had practically returned to what it was previous to operation.

Routine blood pressures taken one hour after the operation showed an average systolic drop of 14.2 mm. of mercury. The diastolic pressure showed an average fall of 7 mm.

In the majority of cases the blood-pressure returned to normal in from four to twenty-four hours following operation. Those cases which were distinctly shocked returned to normal on the second or third day postoperative.

The leukocyte count showed a rapid rise, which was first noted one hour after operation, and increased up to from six to twelve hours. The average rise by the sixth hour was 10,150 cells. Differential leukocyte counts gave a relative increase of the polymorphonuclear cells, their average rise being 14 per cent. The lymphocytes were accordingly reduced, while transitional cells remained unchanged.

SHOCK CONDITIONS, AND DIFFERENTIATION BETWEEN SHOCK AND HEMORRHAGE.

NOW, AFTER ESTABLISHING what occurred as normal phenomena following operation, we considered the changes in a series of cases in which the patients were clinically shocked, presenting the typical clinical picture of shock, with the pinched pale face, cyanotic lips, shrunken eyes, lusterless cornea, dilated pupils reacting poorly to light, cold and clammy extremities, cyanosis of toes and finger tips, diminished reflexes, the general skin surface cold and clammy and bathed in a cold sweat. The respirations were superficial, shallow, and irregular, the temperature normal or subnormal, the pulse was weak, rapid, and occasionally very slow, with a marked drop in the systolic pressure. Yet with the patient presenting such a picture we find a group of cases in which the laboratory findings are negligible. Illustrative of this type is a case of carcinoma of the cervix in which a pan-hysterectomy was done. The patient went on the operating table with detailed preoperative laboratory findings. Her pulse pressure was 50 and the hemoglobin 35 per cent. The blood showed agglutination and hemolysis in the donor. The red cell count was 1,200,000; leukocytes, 9,000, and the coagulation time eight minutes. This patient was subjected to an operation, lasting an hour and a quarter, the greatest care being taken to avoid further loss of blood. She came off the table with a pulse of 130, small and compressible, and with all the clinical symptoms of shock, yet the laboratory picture showed that not only throughout the operation, but during the first twenty-four hours after, the pulse pressure was continously maintained at 50 mm. and the hemoglobin showed no variation. Another patient also suffering from malignant disease of the cervix was subjected to a radical operation which occupied nearly two hours. She was returned to her bed with a pulse of 158 and all the clinical signs of shock, but notwithstanding the laboratory picture showed her to have kept a constant pulse pressure of 35 throughout the first twenty-four hours of postoperative observation. The hemoglobin, leukocyte, or red cell count in this case did not change from the readings of the preoperative records.

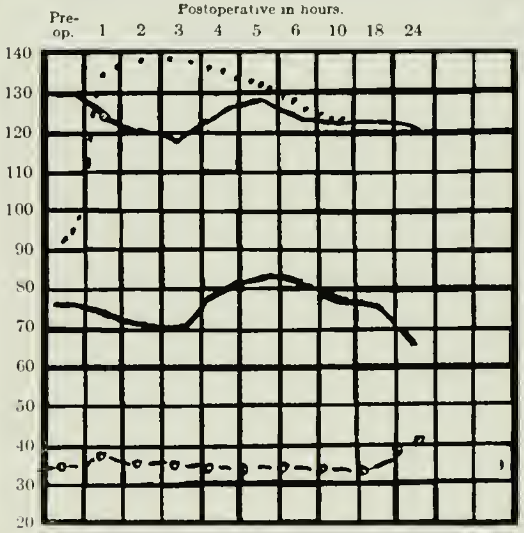
In the second group of cases, while the patients presented the clinical phenomena of shock, we had a definite laboratory picture, which differed so much from that found in the first group that had we not made a very careful and detailed study of these first cases we would have conceded that the laboratory findings made the diagnosis. These cases showed a diminution in the systolic and pulse pressures, with a rise in the hemoglobin and red cell count. In illustration of this class another case may be cited. A woman of small type had a series of plastics, with the removal of the upper segment of the uterus with double tubal infection, following the Bell-Buettner technic. This patient had the usual full preoperative records. The red cell count was 4,200,000, the hemoglobin 75, the leukocytes 8,200, with a blood pressure of 130 over 80. Following the operation we found that the hemoglobin had risen to 85 and the red cells to 5,000,000, remaining high for the first twenty-four hours, not reaching normal until the afternoon of the day following operation. The leukocytes dropped to 6,000. The blood pressure showed a drop of from 130 to 100 systolic and over 70 diastolic. In other words the pulse pressure dropped from 50 to 30 as a result of the operation. This patient was given oxygen inhalations upon the withdrawal of the anesthetic, and reaction occurred thirty-five minutes later. With the reaction we noted an immediate rise in the blood pressure to 125 over 75. After the oxygen was stopped the pressure again dropped to 110 over 78, and it was not until forty-eight hours after the operation that the normal ratio of 130 over 80 was reestablished.

In our third group of cases we were dealing with shock and hemorrhage, and we had supposed that with the aid of the hemoglobin estimation and repeated blood pressure readings we would be able to positively differentiate between shock and hemorrhage. We were, however, doomed to disappointment, as clinical experience shows that unless the hemorrhage has been a frank hemorrhage the hemoglobin estimation and the red cell count show little change, hence have little or no significance in determining the presence of slow bleeding. However, the pulse pressure and an increasing leukocytosis will give valuable information. We know that in ectopic pregnancy, immediately following the rupture, we have a drop in the hemoglobin, a drop in the systolic and pulse pressure, and an increase in the leukocyte count. This, however, is not true where slow bleeding takes place after operation. As you will see in the accompanying chart the hemoglobin percentage may not change even when bleeding is continuous. This patient had a pulse pressure of only 10, yet the hemoglobin remained 65 per cent.

Clinically but two facts stand out in the differentiation between shock and hemorrhage: (1) in hemorrhage the pulse rate is always progressively increased, and (2) the leukocyte count is also increased.

The striking similarity in the clinical manifestations of these two conditions is due to the fact that in hemorrhage the blood is permanently lost from the vessels, while in shock it is accumulated in the large venous trunks of the splanchnic plexus, and therefore is of as little use in maintaining the blood pressure as if the volume of blood was actually outside the body. This, according to Crile, is due to the exhaustion of the vasomotor center, the cardiac and respiratory failures being secondary to the exhaustion of the vasomotor control. While Porter, Mann, Gatch and others accept the peripheral theory of shock it matters not with which side one aligns himself, two facts must be accepted: (1) that the visceral and peripheral arteriols are constricted, and (2) that the veins and venous channels in the splanchnic area are dilated and contain the body fluid. In hemorrhage, if it be of any considerable quantity, one may always expect to find (1) a fall in the number of red cells per cubic millimeter, (2) a decrease in the percentage of hemoglobin, and (3) an increase in the number of white cells, with the maximum increase occurring early. In shock, on the other hand, the diminution in the red cell count does not occur, but there is usually a reduction in the leukocyte count. When the bleeding occurs in the abdominal cavity, which is the most frequent site of internal concealed hemorrhage, in women *the two conditions vary only in the fact that in one* (*hemorrhage*) *the blood is outside the vessels and in the other* (*shock*) *it is inside.* In shock there is always a loss of the circulatory fluid, due to the large quantity of blood which is cut out of the general circulation by the dilatation of the venous channels of the splanchnic plexus. The splanchnic vessels alone, as is well known, are capable of holding several times the total amount of blood in the body. In health there are two factors which prevent the filling of these vessels: (1) the vasomotor apparatus, and (2) the contraction of the abdominal muscles. The first acts by decreasing the amount of flow into the splanchnic area, while the contraction of the abdominal muscles raises the intra-abdominal pressure and diminishes the capacity of the capillary and venous channels.

The flow through these vessels, therefore, depends upon the *vis a tergo of the heart* assisted somewhat by the *rhythmic variations in the intra-abdominal pressure* resulting from the contraction of the *abdominal muscles.* Paralysis of the abdominal walls or laparotomy must reduce the intra-abdominal pressure to that of the atmosphere, and while the heart continues to fill these vessels there is no force to drive the blood out of them. Their capacity is greater than the entire volume of blood in the body, and their walls have no external support. Hence the splanchnic vessels will become immensely distended, and consequently the peripheral blood pressure will drop. This explains the value of posture and sandbag pressure on the abdomen in postoperative shock. Experiments on animals show that life is possible when intra-abdominal pressure has been reduced to that of the atmosphere *only* when the *return of the blood* to the heart is assisted by gravity, *and* when the animal is not required to make any great exertion. In the human abdominal incision causes a sharp decrease in abdominal pressure. Small incisions, short anesthesia, and non-eventration of the viscera minimize the splanchnic paralysis, while large incisions, protrusion, and exposure of intestines are supposed to allow a marked stasis of blood to take place in the abdominal veins. This withdraws a dangerously large amount of fluid from the circulation. Hence, shock is increased.



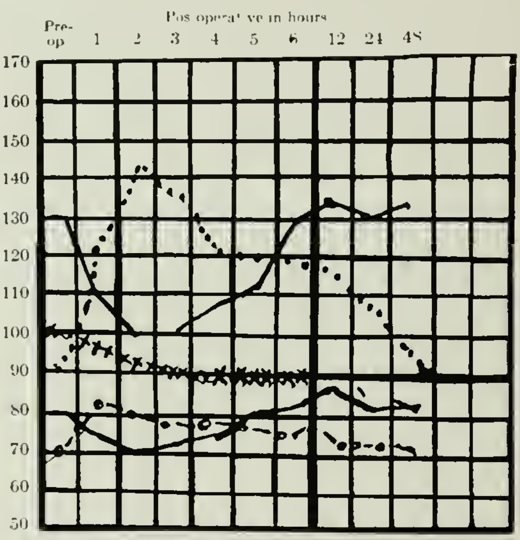
——— blood-pressure. . . . pulse. —o—o— hemoglobin.

CHART I.—Clinical shock, with laboratory findings undisturbed

Gatch has demonstrated that the deeper the anesthesia the greater the accumulation of blood in the abdomen and legs, consequently the blood pressure must be lowered. This is why operations in the Trendelenburg posture under light anesthesia have less shock. When actual blood loss, as occurs in hemorrhage, is added to this intra-abdominal stasis the loss in pulse pressure must be greater. (Illustrative chart.)

CARDIAC DILATATION.

PULSE PRESSURE READINGS taken during the operation have shown that traction on the mesenterics and exposure of the intestine to air increases the pulse rate and lowers the pressure, for exposure causes the intestine to become congested and blue in color, and after prolonged handling it becomes edematous and subperitoneal extravasation of blood occurs and the pulse is accelerated and the pulse pressure falls. The blood pressure falls because there is not enough fluid in the circulation to maintain it. Morphinization at this time changes the picture. In cardiac dilatation our studies show but one constant laboratory finding—namely, lowered pulse pressure. The clinical picture is unmistakable and needs no description to those who are readers of this Year-Book. (Illustrative chart.)



—— blood-pressure . . . . pulse. —o—o— hemoglobin xxxx leukocytes.

CHART II.—Typical example of laboratory findings in shock.

DEDUCTIONS.

THE DEDUCTIONS WHICH one may draw from these studies are:

1. There is a constant rise of from five to fifteen points in the hemoglobin readings following anesthesia with ether when such anesthesia occupies more than thirty minutes. Consequently, allowance must be made for this rise in using hemoglobin estimations as a diagnostic sign in internal bleeding.

2. The erythrocyte count is also increased, but its variation from the preoperative is so slight that it does not warrant any conclusions.

3. In the majority of cases there is a moder-

ate fall in both the systolic and diastolic blood pressure following ether anesthesia. The blood pressure returns to normal—that is to the preoperative reading—in from twelve to forty-eight hours. The inhalation of oxygen after the withdrawal of the ether vapor diminishes this fall in blood pressure, but is only transient in its effect.

4. In cases of shock, especially when there has been much blood loss during the operation, the fall in blood-pressure is greater than after long operation without blood loss, dropping from ten to fifty millimeters.

5. The pulse pressure is a better index of hemorrhage or cardiac failure than the systolic pressure.

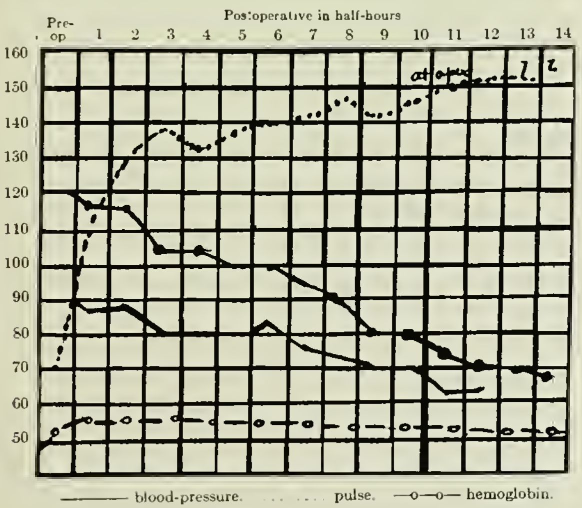


CHART III.—Hemorrhage, with no variation in hemoglobin.

6. There is a constant rise in the leukocyte count in hemorrhage while the leukocytes fall in shock.

My thanks are extended to my resident, Dr. Otto H. Hefter, and my internes, Dr. Shutter and Dr. Curry, for their painstaking work in making the laboratory findings in these series so complete as to allow us to draw these deductions.

RELATION OF PULSE PRESSURE AND KIDNEY FUNCTION TO OPERATIVE PROGNOSIS.

DURING THE PAST two years, at the Long Island College Hospital, we have made an attempt to determine the *clinical value of preoperative pulse pressure* and its relation to kidney function in the operative prognosis of gynecologic patients. This study has been carried out along with our routine preoperative and postoperative blood pressure and blood studies, the preliminary report of which has already been presented to the American Gynecological Society at its 1917 meeting and published in their transactions. The conclusions of this former study will be given at the close of this brief discussion.

CARDIAC FORCE.

IN ORDER TO make these determinations, the *following preoperative routine has been adopted:* On admission *the cardiac force* of each

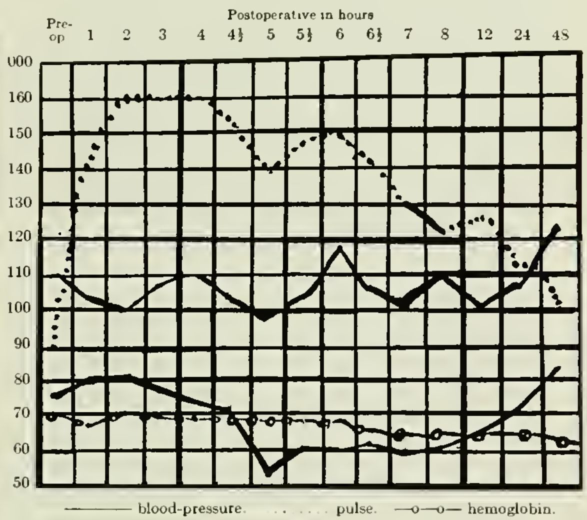


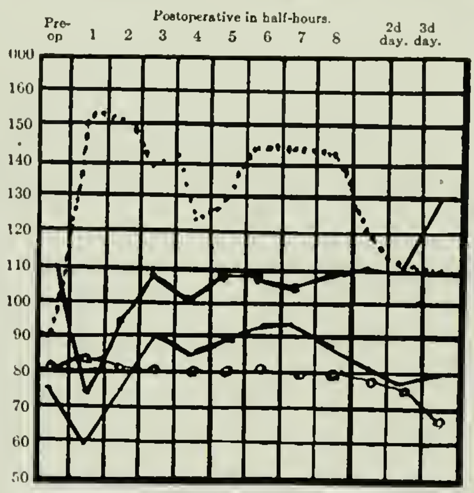
CHART IV.—Cardiac dilatation. Strophanthin given four and a half hours postoperative.

patient is studied in the following manner: The systolic and diastolic pressure is taken with the patient in the recumbent position, and the pulse pressure noted as *at rest.* The patient is then seated on a stool and instructed to raise the arms and extend and flex the forearms for two minutes, when the systolic and diastolic pressures are again taken and the pulse pressure noted and recorded, as *after moderate exercise.* Finally the patient is made to stand up with the legs spread apart and a pound weight lying between the feet, when she is directed to raise the weight up over her head, then lower it between her legs again, then raise it again, first ten times, then twenty times. The *rate of the heart action is, of course, accelerated* and the *systolic pressure raised,* but if the *heart muscle is of good quality little or no change is noted in the pulse pressure.*

The value of such a test is at once apparent in estimating the quality of the cardiac muscle, especially in those women who have been ill with infective diseases for a long time.

PHTHALEIN OUTPUT.

WE NEXT MAKE a preoperative estimation of the *sulphophenolphthalein output of each patient, to estimate the renal function.* We have found that, *averaging the normal pulse pressure at 35 millimeters, the "phthalein" output for two hours, in the normal case, averages about 60 per cent.* Where the *pulse pressure is high, say 60 or 70 millimeters,* the *"phthalein" reading will be either high or low, depending on the state of the kidney structures.* When the *reading is low, the pulse pressure has to be relatively high to compensate for the diminished renal function.* On the other hand, when the "phthalein" reading is low, say *20 or 30 per cent. in two hours,* and the *pulse pressure also low, the patient has proven to be a poor operative risk and the cardiac muscle is always questionable.* These patients have given us trouble in their postoperative course.



——— blood-pressure. . . . . pulse. —o—o— hemoglobin.

CHART V.—Shock with operative hemorrhage. One ampoule of strophanthin given intravenously.

Our only fatal case, of postoperative cardiac dilatation, showed a preoperative pulse pressure of 24 and a "phthalein" output of only 29 per cent. Under ether stimulation and the Trendelenburg posture, the pulse pressure was maintined throughout the entire operation at 30 millimeters, but promptly on her return to bed and after the effect of the ether had worn off, the pressure dropped to 20 millimeters, and resisted all known methods to raise it. The patient died five and one-half hours after coming from the operating room.

Such an experience led us to make a further study of the effect of ether on renal function as shown by the phenolsulphonephthalein output.

RELATION OF PULSE PRESSURE AND KIDNEY FUNCTION.

OUR ROUTINE has been, for several years, to watch the pulse pressure during anesthesia and to take the systolic and diastolic pressures *immediately at the close of every operation,* while the patient was still under ether stimulation, *again in six hours* and *again in twenty-four,* and a record of the *pulse rate every fifteen minutes for the first six hours.* In shock or hemorrhage the pressure is taken every hour until reaction has taken place. A complete blood count and hemoglobin estimation is also made immediately on the return of the patient from the operating room. This *gives us a control for comparison with pressures and counts,* should complications occur in the subsequent postoperative course. *No step in our routine has been of more clinical value than this detail,* as by it alone and in conjunction with blood pressure readings, we have been able to differentiate between hemorrhage shock and postoperative cardiac dilatation.

Six hours after operation the first "phthalein" estimation is made of the kidney function. A catheter is left in place for two hours and the readings made from the collected urine. So far in our work *one interesting observation has been noted, namely, that notwithstanding the diminished urinary output which always follows the administration of ether in the first few hours, there is only a negligible change, usually not over*

10 per cent. in the "phthalein" eliminated, provided the pulse pressure has remained normal.

EXCEPTIONS.

BUT THREE EXCEPTIONS to this constant observation have been noted, *one a nephrectomy for a large cystic kidney where* the *immediate effect* of *removal of the kidney was to reduce the "phthalein" output from 85 per cent. preoperative to 29 per cent. postoperative,* yet within thirty hours the output had increased to 65 per cent.

Another exception was a myomectomy in which there was considerable blood loss during the operation with a consequent fall in pulse pressure, a half grain of morphin was used during the last half of the operation while the administration of ether was suspended. The operation was followed by severe shock, the blood pressure fell to 78 over 55 millimeters, and remained so for several hours. The urinary output in the first twenty-four hours was 4 *ounces* and the "phthalein" elimination only 20 per cent. It took seventy-two hours before the urinary output and kidney function approached the preoperative record. This is a good illustration of the relation of pulse pressure to kidney function.

A third case, which shows a marked discrepancy between preoperative and postoperative readings, was that of a woman with a large subvesical myoma, who was subjected to a total hysterectomy. Her hemoglobin on admission was only 40 per cent. The systolic pressure 150 over a diastolic of 110 millimeters. This patient showed a preoperative functional "phthalein" of 65 per cent. after twenty-four hours of preoperative rest. She had a light ether anesthesia of nearly an hour, supplemented by a half grain of morphin during the operation. She left the operating table with a pulse of 80 of good quality and a pressure of 155 over 115 millimeters. Her "phthalein" at the end of six hours was 20 per cent. and only 10 ounces of urine was secreted in the first twenty-four hours. This increased to 26 ounces in the second twenty-four hours as did her "phthalein" which rose to 40 per cent.

These two instances suggest to us that while *morphin definitely minimizes the shock* and *may be used to advantage* when *the patient is fully anesthetized to complete the operation without the further administration of ether,* it has the effect of diminishing the urinary output in the first few hours after operation.

In the second case, the low pressures may have had a direct bearing on the kidney output, but in the last the pressure remained constant and cannot be credited with inhibiting kidney function, nor in this case was there any blood loss or shock, hence I feel that it is fair to conclude that the diminished output was directly due to morphin.

CONCLUSIONS.

FROM THIS SHORT STUDY, which now includes more than 200 consecutive abdominal cases, we feel justified in drawing the following conclusions:

1. That the *pulse pressure is a test of the muscular strength* of the *individual woman's heart,* when endocardial lesions can be excluded.
2. That the *efficiency of the kidney function is directly dependent on the cardiac force of the individual, provided the kidney structures are normal or approximate the normal.*
3. That *ether anesthesia of an hour does not disturb the relation of pulse pressure to kidney function unless the operation is accompanied by considerable blood loss.*
4. That when *the preoperative kidney function is low the pulse pressure must be relatively high to compensate for the deficiency,* as it does *no good to add saline by skin or bowel or infusion unless there is sufficient cardiac* strength to take it up and carry it along.
5. That *when both the pulse pressure and "phthalein" output are low the operative prognosis should be guarded.*
6. That *morphin in large doses during operation seems to help in diminishing the shock* but has a definite effect in diminishing the kidney output.

THE IMPORTANCE OF TEMPERATURE IN RELATION TO ANESTHESIA . DIFFERENT EFFECTS OF HEAT AND COLD IN HEALTH AND OPERATION . DURING SLEEP AND UNDER ANESTHESIA . RESULTS OF ANIMAL AND HUMAN EXPERIMENTAL OBSERVATIONS . DETERMINING FACTORS . METHODS OF OBSERVATION . TABLES OF RESULTS . CONCLUSIONS . RELATIVE VALUE OF SO-CALLED WARMED AND UNWARMED ETHER VAPOR . RELATIVE TOXICITY . PRODUCTION OF SHOCK . POSTANESTHETIC CONVALESCENCE . HEAT LOSS . LOCAL IRRITATION . CHEST COMPLICATIONS . SUMMARY AND CONCLUSIONS . EXPERIMENTAL RESEARCHES IN THE WARMING OF NITROUS OXID-OXYGEN FOR ANESTHESIA . EXPERIMENTAL APPARATUS . SOME CLINICAL OBSERVATIONS ON THE EFFECTS OF WARMED NITROUS OXID.

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JOINING THEIR laboratory work and hospital experiences, M. S. Pembrey, and F. E. Shipway, of London, England, have considerably illuminated the question of the importance of temperature in relation to anesthesia. Their conclusions were published in Guy's Hospital reports, October, 1918. Shipway's contentions secured the widespread clinical endorsement of war service and his apparatus for warmed and oxygenated C-E vapor was very extensively and successfully employed in hazardous cases.

The influence of temperature upon the exchange of material in animals has been long recognized by physiologists, and during experiments involving operations under anesthesia they have been accustomed to take precautions to maintain the bodily heat. Surgeons following the teaching of physiology have adopted similar precautions. The custom is well established, even if the reasons have not been fully appreciated. In this paper, which is based both upon physiological experiments and clinical experience, we propose to consider the influence of temperature during anesthesia.

The temperature of the body in warm-blooded animals is an expression of the metabolism or exchange of material; in other words it represents the oxidation or combustion which occurs in the tissues. The relationship between the temperature of the deep parts, such as the rectum, the closed axilla or groin, and superficial parts, such as the skin, is an expression of the efficiency of the nervous control exercised upon the production and loss of heat. The activity of a tissue is accompanied by an increased temperature in the part, and, therefore, it is possible from a study of such changes to obtain indications for the proper use of heat and cold as therapeutic agents.

DIFFERENT EFFECTS OF HEAT AND COLD IN HEALTH AND OPERATION DURING SLEEP AND UNDER ANESTHESIA.

IT IS NECESSARY as a preliminary to insist upon the difference between the effect of heat and cold upon a healthy man with full control over the production of heat in his tissues and the loss of heat through the blood exposed in the vessels of his skin and the anesthetized subject, who, as the result of the anesthetic, has lost the normal sensations of heat and cold and the control over both the production and loss of heat. The former on exposure to cold increases the production of heat in his body and diminishes the loss by contracting his cutaneous vessels; the latter does not react in this way, for he is more or less paralyzed by the anesthetic.

The healthy man in a condition of profound rest, such as a deep sleep, is not comparable to an anesthetized subject, although the comparison between surgical anesthesia and sleep has often been and is still made. During sleep the muscles are in a condition of tone and are not paralyzed, and there are responses to tactile and thermal stimuli; on the other hand, the excitability of the nervous system is undoubtedly lowered during sleep, the metabolism is diminished, and the temperature falls; indeed, there is evidence that the regulation of the production and loss of heat is imperfect. In surgical anesthesia the object is to produce paralysis, and such a condition must involve changes in all the systems of the body. The body works as a whole, and a general anesthetic, as opposed to a local anesthetic, will have a profound effect; the paralyzed muscles will produce less carbon dioxid and less heat, the nervous system will not respond readily to external stimuli, the regulation of temperature will be abolished, and the chemical changes in the cells of the body will follow the ordinary law, that is, will rise and fall with the temperature. The respiration and circulation have been regarded as the most important systems to consider during anesthesia, and temperature has an important effect on both. A rise of temperature increases the excitability of the respiratory center and quickens the heart beat.

RESULTS OF ANIMAL AND HUMAN EXPERIMENTAL OBSERVATIONS.

AFTER THIS INTRODUCTION it will be well to consider in more detail the chief points and to illustrate them by the results of experiments upon animals and observations upon man.

In the first place, anesthesia reduces the output of carbon dioxid and the intake of oxygen; in small mammals, such as the mouse, the reduction may be as great as one-half the normal value, as shown by the following examples:—

14/iv./93.—Black and white mouse No. 1 in the ventilated chamber, water bath = 10.5° C. for 8 minutes before the first period. Consecutive periods of 20 minutes.

Output of carbon dioxid in decimgrms.	Temperature of water bath, C.	Remarks.
931	10.5°	Normal.
482	11	Anesthetized by ether.

7/v./93.—Black and white mouse No. 1 in the ventilated chamber, water bath = 14° C. for 5 minutes before the first period. Consecutive periods of 30 minutes.

Output of carbon dioxid in decimgrms.	Temperature of water bath, C.	Remarks.
1216	14°	Normal.
629	14.25°	Anesthetized by ether.

In larger mammals, such as the rabbit, experiments show that the reduction in the respiratory exchange is much less; this is related, as will be mentioned later, to the slower cooling of the animal. It would follow as a result of the reduction of metabolism that there should be a fall in the temperature of the body, unless the loss of heat were reduced. It is, indeed, well known that the internal temperature of the body may reach a very low level if no precautions are taken to diminish the loss of heat. During anesthesia very low records would not be found in man except in the case of accidents or suicidal attempts, but in drunkards exposed to cold, rectal temperatures as low as 75.2° F. (24° C.) have been observed, and the patients have recovered under careful treatment and nursing. In animals it is well known that a considerable fall in the rectal temperature may occur during anesthesia. The following are examples from our observations:—

Animal.	Rectal Temperature. Before Anes-thesia.	After Anes-thesia.	Method and Duration of Anesthesia.	Tempera-ture of air of room.
Rabbit	38.5°C.	34.5°C.	Open ether for 29 minutes followed by warm ether for 29 minutes.	14°C.
		32.0°		
Rabbit	38.25°	35.0°	Warm ether for 29 minutes followed by open ether for 28 minutes.	14.5°
		31.5°		

The contrast in the response of the normal animal and of the same animal under anesthesia to changes of external temperature is very definite, and is shown by the following examples:—

Black and white mouse in the ventilated chamber, water bath = 28° C. for 10 minutes before the first period. Consecutive periods of 10 minutes.

Output of carbon dioxid in decimgrms.	Temperature of water bath, C.	Remarks.
202	30°	Mouse quiet.
212	29°	Mouse washing itself.
185	27.75°	Mouse active.
345	13.5°	Mouse very active, trying to get out.
350	13.75°	Mouse very active, trying to get out.
365	14°	Mouse very active, trying to get out.

Black and white mouse A in the ventilated chamber, water bath = 25° C. for 50 minutes before the first period. Consecutive periods of 15 minutes.

Output of carbon dioxid in decimgrms.	Temperature of water bath. C.	Remarks.
437	25°	Mouse sent under ether.
392	25°	Mouse under ether.
290	13.5°	Mouse under ether.
308	13.5°	Mouse under ether.
185	13.5°	Mouse under ether.

The mouse was fully under ether when taken out of the respiration chamber. It took about 15 minutes to recover from the anesthetic.

The normal animal responds to external cold by muscular activity which increases the production of heat and carbon dioxid; within 10 minutes of a change of external temperature from 27° to 13° C. the discharge of carbon dioxid was almost doubled. On the contrary, a similar fall of external temperature produced the opposite effect in the anesthetized animal.

DETERMINING FACTORS IN THE INFLUENCE OF WARMTH UNDER ANESTHESIA.

IN DISCUSSIONS UPON the influence of warmth during anesthesia, there has been in many cases a misunderstanding of the complexity of the problem. The important factor is not the actual amount of heat which may be communicated to the patient, but the effect of a high external temperature upon the production of heat in the body.

Anesthesia must be considered in relation to its intensity and duration. Light anesthesia will not produce such profound effects, for the paralysis of muscles and the regulation of metabolism are in proportion to the depth of anesthesia. The duration of the anesthesia is another factor which complicates the results. A big animal or a patient starts with a certain reserve of heat, and the temperature of the mass of the body is not easily altered in a short time. This latency may be well seen after the operation is over, the lowest record may then be obtained. In the same way it is difficult to raise rapidly the temperature of the body by external sources of heat. Thus it follows that the anesthetist should pay attention to the temperature before, during, and after an operation. It is obvious also that the duration and extent of the exposure of the skin and the viscera during operations must be taken into account.

The custom of giving morphin before operations is now so general that it should receive some attention here. The small doses given in civilian practice do not intensify to any great extent the effect of the anesthetic upon the temperature, but there is evidence that in the Navy and Army the drug has been administered in doses so large as to produce a considerable fall of temperature, especially when the patient has been exposed to cold.

METHODS OF OBSERVATIONS.

THE OBSERVATIONS WHICH form the subject of this paper were made (chiefly by F. E. S.) upon patients in the ordinary surgical practice of Guy's Hospital. The thanks of the authors are due to the surgeons for the facilities they have afforded and the kind interest they have taken in the work, and also to the sisters and nurses for valuable assistance.

The records were made before, during, and after anesthesia (conducted by F. E. S.), and relate to both surface and deep temperatures. The former were determined by a mercurial thermometer with a flat bulb, the latter by a clinical thermometer in the rectum, for it has been shown that the mouth does not represent the real internal temperature of the body. For examples the following may be given:—

Case.	Disease.	Temperature of mouth.	Temperature of rectum.
15	Acute appendicitis and general peritonitis.	95.5°	100.8°
22	Strangulated inguinal hernia.	96.8°	99.6°
66	Malignant disease.	99°	100.4°
64	Appendicitis.	99.2°	100.4°

The operations were almost invariably performed in the afternoon between 2 p. m. and 6 p. m., and on this account variations in the temperature of the body due to the time of day are excluded. The method of *open ether* used is that in which ether is dropped continuously on to some fabric spread over a Schimmelbusch mask, which is so closely applied to the face that the whole of the respiratory current passes through the fabric; when *warm ether* is given, the end of the tube from the apparatus[1] (Shipway's) is placed under the mask and ether vapor pumped in at each inspiration. With this method the temperature under the mask through which the patient is breathing varies from 48.2° to 86.9° with open ether, and 87.8° to 93.2° with warm ether. There is little doubt that with minimum and maximum thermometers a greater range would be recorded in the case of open ether, but from a practical standpoint the reading of an ordinary thermometer is the most important. The *temperature in the airway* represents the observations made upon the air in the mouth respired through a Hewitt's airway.

In most cases the administration of the anesthetic was preceded by a subcutaneous injection of $\frac{1}{6}$th grain of morphin and $\frac{1}{100}$th grain of atropin, or of atropin alone. Induction was usually carried out by C. E. mixture (C_2E_3) upon an open mask.

The cases have been arranged according to three factors: method of anesthesia, age of patient, and temperature of the operating theatre. Group I, relates to ages between 16 and 66 years, Group II, to ages between four weeks and 15 years.

The Groups are subdivided into Section A for the range of external temperature between 67.1° and 75.2° (19.5° and 24° C.), and Section B for the range 75.2° and 85.28° (24° and 29.6° C.); these sections are in turn divided into two Parts (i.) Warm Ether and (ii.) Open Ether. (See Tables.)

In considering the results of these observations it is necessary, as far as possible, to make allowance for the influence of the various accessory factors, which might complicate the effects, such as the severity and duration of the operation, the exposure of viscera, and the condition of the patient. This can be done in some measure by taking the average of the results and at the same time giving the range of the variations in the deep and surface temperature. The next table was constructed on that plan.

An examination of the table shows that there

1. Shipway, F. E.: Lancet, January 8, 1919, p. 70.

is a definite influence exerted by the warm ether, when the other conditions are as far as possible comparable. The contrast between anesthesia by *warm ether* and *open ether* is more clearly shown when the results are expressed in percentages, as in the following table:—

Group.	Section.	Age of patients.	Temp. of air of operation theatre.	Rectal temperature.			Surface temperature of forearm.				Surface temperature of thigh.				Method of Anesthesia.
				Rise.	Fall.	No change.	Rise.	Fall.	No change.	No Record.	Rise.	Fall.	No change.	No Record.	
I.	A (i.)	16 to 66 years	67.1 to 75.2°	18.2	72.7	9.4	68.2	9.1	18.2	4.5	31.8	50.0	13.6	4.6	Warm ether.
I.	A (ii.)	ditto	ditto	4.0	96.0	—	76.0	16.0	4.0	4.0	20.0	68.0	8.0	4.0	Open ether.
I.	B (i.)	ditto	75.2 to 85.28°	26.7	46.6	26.7	80.0	6.6	6.7	6.7	46.6	40.0	6.7	6.7	Warm ether.
I.	B (ii.)	ditto	ditto	18.8	75.0	6.2	81.2	18.8	—	—	31.3	62.5	6.2	—	Open ether.
II.	A (i.)	4 weeks to 15 yrs.	68 to 75.2°	43.7	31.3	25.0	81.2	6.3	—	12.5	50.0	25.0	—	25.0	Warm ether.
II.	A (ii.)	ditto	ditto	15.8	79.0	5.2	84.2	5.3	10.5	—	26.3	52.7	10.5	10.5	Open ether.
II.	B (i.)	ditto	75.2 to 85.1°	54.5	27.3	18.2	81.8	—	—	18.2	63.6	18.2	—	18.2	Warm ether.
II.	B (ii.)	ditto	ditto	28.6	57.1	14.3	85.7	14.3	—	—	—	71.4	28.6	—	Open ether.
All	All	All	All	35.8	44.5	19.8	77.8	7.3	12.4	—	48.0	33.3	10.1	—	Warm ether. 64 cases.
All	All	All	All	16.6	76.8	8.6	81.8	13.6	7.2	—	25.9	63.6	13.3	—	Open ether. 67 cases.

It will be observed that the number of cases of a rise in the surface temperature of the forearm during anesthesia is similar throughout all the sections, but there are more cases of a fall of temperature with the *open ether* as well as fewer cases of no change in temperature. In the case of the surface temperature of the thigh the advantage of the *warm ether* in maintaining the temperature of the body is definite. There may be several explanations of the contrast between the changes in the surface temperatures of the forearm and thigh during the two methods of anesthesia; it might be due to the more complete covering of the arms and their close approximation to the body; on the other hand there is the possibility of causes connected with the circulation, either the shorter circuit in the forearm or differences in vasomotor control over the upper and lower limbs. Since no special observations have been made to test these possible explanations, it is unnecessary to say more.

As regards the influence of atropin, there is some evidence of vasodilator action upon the skin, as shown in the following examples. The combined action of morphin and atropin shows no more definite effect upon the temperature as far as our observations go.

The few cases of anesthesia with chloroform or chloroform and ether have been collected as well as the cases of patients with a pyrexial temperature; in the latter there are seven cases of *warm ether* and two of *open ether* anesthesia, but the number of cases is too small to justify conclusions being drawn.

An examination of all the records shows no higher rise of rectal temperature during the anesthesia with *warm ether* than 2.8° in case 74, a child with an initial temperature of 98.6°, one of 101.4° after the operation, 99.8° two hours later, and 99.2° four hours later. Deep anesthesia will paralyze the regulation of the temperature of the body, and it is possible, as experiments on animals prove, to produce hyperthermia even of a fatal nature by excessive external heat. In man, however, these conditions would very rarely, if ever, arise, for the exposure of the body during an operation and the vasodilator effect of the anesthetic would prevent any serious rise of the internal temperature. It should be stated further that in some of the cases given in this paper were any untoward effects of the anesthetic observed; as a general rule the aim has been as light an anesthesia as was consistent with the requirements of the operation.

confirm the clinical conclusion that the vitality and resistance of the patient are better maintained under *warm ether*. This advantage in the case of long operations or operation upon a patient

Case.	Temperature of skin.				Temperature of Rectum.		Interval.	Injection.
	Forearm.		Thigh.					
	Before.	After.	Before.	After.	Before.	After.		
68	84.2°	89.6°	—	—	100.2°	—	60 minutes	1/150 gr. of atropin
71	95.0°	96.8°	96.35°	96.8°	99.4°	99.4°	100 minutes	1/100 gr. of atropin
34b	95.0°	95.18°	95.9°	97.25°	99.2°	99.2°	35 minutes	1/100 gr. of atropin
30b	92.12°	93.74°	95.45°	95.45°	99.6°	99.2°	60 minutes	1/6 gr. of morphin 1/100 gr. of atropin
36b	93.2°	93.65°	96.1°	97.25°	100°	100°	30 minutes	1/100 gr. of atropin

possessing a low resistance may make all the difference between success and failure.

CONCLUSIONS.

A COMPARISON OF 64 cases of anesthesia with *warm ether* and 67 cases with *open ether* proves that the former method maintains the temperature of the body in a far more efficient manner than the ordinary means of preventing loss of heat when the latter method is used. Thus, with *warm ether* the respective percentages of rise, fall, and no change of rectal temperature were 35.8, 44.5, and 19.8 as against 16.6, 76.8, and 8.6 with *open ether*.

A detailed analysis of the cases arranged according to age and temperature of the air of the operation theatre shows that the advantage in each section lies with the *warm ether* method.

The great practical advantage of the *warm ether* is that it enables the surgeon to operate in a cooler theatre; the patient can be kept warm without exposing the staff to the depressing effect of high temperatures. Apart from diminished efficiency and endurance, a warm and moist atmosphere introduces the danger of the sweat of the surgeon and his assistants undoing the elaborate precautions taken to preserve aseptic conditions.

The observations upon man agree with the physiological experiments upon animals [2, 3] and

2. Pembrey, M. S. and Shipway, F. E.: Proc. Roy. Soc. Med., Vol. ix, 1916, No. 7.
3. Pembrey, M. S.: Proc. Physiol., Journ. Physiol., Vol. xvii, 1895, p. iv; Vol. xv, 1894, p. 401.

DIFFERING FROM OTHER observers, Benjamin F Davis and F. B. McCarty, of Chicago, Illinois, consider the relative value of so-called warmed and unwarmed ether vapor as unimportant from the standpoint of safety, efficiency and comfort. At the Fourth Annual Meeting of the American Association of Anesthetists, they presented their data, worked out in the Laboratories of Rush Medical College and in the Clinics of the Presbyterian Hospital, of Chicago, and their findings were such as to warrant careful consideration.

In this paper an attempt will be made to summarize the evidence bearing on the use of warmed and unwarmed ether vapor in anesthesia. By unwarmed ether vapor is understood ether vapor which has not been passed through some specially devised heating apparatus before delivery to the patient.

The average temperature beneath the mask when ether is administered by the open drop method is about 32° C—that is, relatively near body temperature. We may therefore eliminate the necessity of any apparatus to warm ether given by the open drop method since the enclosed space in front of the mouth, provided by the cone, forms a natural warming chamber from which the air-ether mixture is delivered into the mouth at a temperature approximating that of the body. McCarty and Davis[1] have shown that the further increase in heat in such cases is gained by the time the mixture has entered the pharynx, so that the entire warming process is accomplished before the anesthetic enters the respiratory tract proper.

In considering the advisability of warming ether vapor when delivered by other methods, the available data will be presented from the standpoint of safety, efficiency and comfort.

RELATIVE TOXICITY.

IN 1906 THERE was published[2] the results of a series of experiments with chloroform vapor on cats from which it was concluded that unwarmed chloroform vapor was 2½ times as toxic as warmed vapor. Since then the same author has investigated the effects of warmed and unwarmed ether vapor and nitrous oxid gas on cats, rabbits and guinea pigs, confirming his belief in the excessive toxicity of unwarmed anesthetic vapors.[3] This conclusion, if correct, would make the use of warmed vapors imperative. On examination of the reports of these experiments, however, it appears that by *toxicity* is meant anesthetizing power; that the same organs are similarly affected by warmed and unwarmed vapor, but that the latter produces its effects more rapidly. Accordingly, if unwarmed vapor is 2½ times as potent as is warmed vapor the anesthetizing and lethal doses of the former should be two-fifths that of the latter. In other words, if anesthesia could be maintained for ten minutes with one ounce of ether in the form of unwarmed vapor it would be necessary to use 2½ ounces of ether during the same time if anesthesia were continued with warmed vapor. There are certain facts which lead us to question the validity of such an assertion. In the first place, certain advocates of the use of warmed vapor have stated that warming the vapor decreases the amount required to maintain anesthesia and that the vapor will act with increased rapidity in proportion to its warmth.[4] Secondly, in a series of experiments on dogs, in which warmed and unwarmed vapor was administered directly into the trachea, we were unable to detect any difference in the quantity of ether required by the one or the other method to induce or maintain anesthesia. Moreover, anesthetic vapors, regardless of the method of administration, reach the alveoli at body temperature; even the small amount which may be absorbed through the mucous membrane of the nose and throat must be at body temperature when it reaches the capillary walls. When one considers the area of the respiratory surfaces and the mass of the body and circulating blood on the one hand and the mass and volume of anesthetic vapor of low specific heat on the other, it is inconceivable that the anesthetic could go into solution in the blood without instantly attaining body temperature. Therefore, no matter how cold the vapor may be when it enters the mouth, it is at blood temperature when absorbed and carried to the medulla, so that it seems impossible that variations in temperature outside of the body could in any way modify toxicity.

Careful examination of the reports shows a possible source of experimental error which may suffice to explain the findings without assuming a decrease in the toxicity of the vapors when warmed. In his work the investigator used a modified Junker inhaler, which consisted of a rubber bulb by which air was pumped through an ether bottle into a face mask provided with valves. The valves were so arranged that on inspiration the only source of air was the ether bottle, while on expiration the air escaped di-

1. McCarty and Davis: Annals of Surgery, 1916, Vol. lxiii, 305.
2. Gwathmey: Jour. A. M. A., 1906, Vol. xlvii, 1361.
3. Gwathmey: Anesthesia, 1914.
4. Hervey: New York Med. Jour., 1913, Vol. xcvii, 344.

rectly from the mask. Connected directly to the face mask was a very delicate rubber bag which served as an indicator and safety reservoir to prevent negative pressure in the face mask. The object of the experiments was to determine the rate at which animals were anesthetized and killed; in order to be certain that all of the animals received approximately the same volume of anesthetic vapor the latter was pumped into the mask at a rate sufficient to keep the indicator bag two-thirds filled. When the vapor was warmed it tended to expand and the indicator distended proportionately. As the degree of distension of the indicator bag was the criterion of the volume of vapor being administered, any distension beyond the standard would be compensated for by decreasing the rate at which the air was pumped through the ether. It would seem, therefore, that the animals which received unwarmed vapor were anesthetized and killed more quickly than those receiving the warmed vapor, because they were given, not a more toxic, but a more concentrated ether vapor.

In our experiments[1] (mentioned above) the vapor was administered at a rate sufficient to maintain complete surgical anesthesia. By subtracting the number of cubic centimeters of liquid ether remaining in the ether jar from the number there at the beginning of the experiment and dividing the result by the duration of the anesthesia in minutes, it was possible to calculate the average rate at which the anesthetic was required. Thus it was found that the amount of ether required to induce or to continue an already induced anesthesia did not vary when the vapor was delivered alternately unwarmed and warmed, to the same animals. After the first half hour anesthesia was maintained by an approximately 6 per cent. ether vapor whether unwarmed or warmed.

We may conclude that there is no satisfactory theoretical or experimental evidence that anesthetic vapors are made less toxic by being warmed; that there is evidence which suggests that warming the vapors makes little difference in the amount required to induce or to maintain anesthesia.

PRODUCTION OF SHOCK.

IT HAS BEEN stated that the nergy used in warming ether vapor to body temperature is a considerable factor in the production of postanesthetic shock. The sources of these deductions have been in the main clinical observations of postanesthetic convalescence and observations on the fall of temperature during anesthesia.

POSTANESTHETIC CONVALESCENCE.

CLINICAL OBSERVATIONS ARE necessarily inaccurate because of the accompanying operative procedures and because of inability to properly and uniformly control other sources of heat radiation and use of energy. Some observers have stated that patients anesthetized with unwarmed vapor come from the operating room pallid, drenched in perspiration, vomiting and often in a state bordering on collapse, and imply that such conditions are attributable solely to the refrigerating effect of the anesthetic. In contrast to this is the opinion of observers such as Dr. Isabella Herb, who in a personal experience covering over 30,000 cases anesthetized with an open mask or by unwarmed vapor administered intrapharyngeally, has found no such alarming conditions due to a well-administered anesthetic per se, even after prolonged anesthesia.[5]

HEAT LOSS.

THERE IS NO doubt but that during anesthesia there is a progressive fall in body temperature, nor is there any doubt that the process of warming cold vapor to body temperature abstracts energy from the body. That the total fall in temperature is due to this use of energy is obviously not the case, for the factors of skin radiation and activity of sweat glands are of definitely greater importance in the dissipation of body heat. The question arises as to whether prevention of loss of heat by way of the respiratory tract is necessary or desirable. It has been demonstrated[1] that the coldest ether-vapor-air mixture which is ever likely to be used for anes-

5. Herb: Jour. A. M. A., 1916, lxvi, 1376.

thetic purposes reaches a temperature of 8.5° C. and that the amount of heat required to raise to 37.5° C., a quantity of such vapor sufficient for an hour's anesthesia is approximately 3.95 Cal. The amount of energy expended in breathing air in an operating room at 27° C. (80° F.) is 1.15 Cal. per hour when no anesthetic is used, so that the increased energy required to breathe ether-vapor-air mixture at its minimum temperature is about 2.80 Cal. per hour. When passed through rubber tubing in a warm operating room the temperature of the vapor as it reaches the patient is considerably higher than 8.5° (at room temperature—Herb) and 1.0 to 1.5 Cal. will usually represent the heat expended in actual practice. Such a heat loss in a 150-lb. man could hardly be detected on a clinical thermometer. Any considerable drop in body temperature must therefore be due to other factors. Davis[6] published the results of clinical observations which seemed to indicate that the use of unwarmed ether vapor was responsible for an average heat loss which would be equivalent to 27.3 Cal. in patients weighing 150 pounds. This is a loss far in excess of what could be accounted for by the use of the coldest vapor one is likely to obtain from any vaporizing machine, so that it would seem that other factors must be responsible for the greater part of this decrease.

In an as yet uncompleted series of observations on dogs the authors have noted that, in a general way, there occurs a tremendous variation in the range of temperature in dogs of the same weight anesthetized under the same conditions, either by the open drop method or with unwarmed or with warmed ether vapor, and have also noted that the fall in temperature in dogs which have been subjected to abdominal section is greater than in those upon whom extra abdominal operations have been performed.

Dr. Isabella C. Herb and Dr. Frances Haines have furnished us with the following data gained from observations on a series of thirty-five patients anesthetized by the open drop method:

6. Davis: Johns Hopkins Hospital Bull., 1909. Vol. xx. 118.

Number of patients—
- (a) males = 19
- (b) females = 16 — Total 35.

Average duration of administration of anesthetic—
- (a) males = 35 min.
- (b) females = 35 min. — 35 min.

Average fall in temperature—(rectal)—
- (a) males = .36° C.
- (b) females = .15° C. — .26° C.

Average cone temperature—
- (a) males = 31.35° C.
- (b) females = 32.2° C. — 31.9° C.

Average room temperature 27.0° C.
Average amount of liquid ether 154.2 cc.
- (a) males 183.0 cc.
- (b) females 120.0 cc.

Through the kindness of Miss Emma M. Rohtge, head nurse of the children's department at the Presbyterian Hospital, we are enabled to present the results of a few observations on the changes in body temperature during natural sleep. Observations were made only on children who were without fever and who were otherwise without abnormalities which might be expected to cause variations in temperature. The rectal temperature was taken in the evening in each case just after the child had fallen asleep and again after an interval of two hours without waking the child. In eight of the children, two or three such observations were made in the course of a week; in two there was but one such observation.

Number of children—
- (a) male = 5
- (b) female = 5 — 10

Average age of children—
- (a) male 9.6 years
- (b) female 7.2 years — 8.4 years.

Average fall in rectal temperature during two hours of natural sleep—
- (a) male .9° F. = .5° C.
- (b) female .42° F. = .23° C. — .66° F. = .44° C.

In comparing these two sets of observations two very noticeable similarities appear. First. in each, there is a definite decrease in body temperature following the onset of unconsciousness; second, in each, the decrease in the temperature of the males is more than double that of the females. The fall in the temperature of the children comfortably asleep in bed for two hours is nearly twice that of the patients anesthetized with ether for 35 minutes.

Without entering into an exhaustive exposition of the subject, the evidence suggests that the decrease in body temperature due to etherization is strictly analogous to that occurring in natural sleep; but that it is a purely physiological process, and as such, cannot be regarded as evidence of pathological changes in the tissues.

A difference between natural sleep and sleep due to an anesthetic is that, as a general rule, if the body temperature approaches pathological extremes during natural sleep, the body is irritated even to the point of wakefulness, until protection is obtained, while during an anesthetic sleep, especially deep surgical anesthesia, there is no such mechanism for self-protection, and a dangerous fall in temperature may ensue if the body is not protected by sufficient covering. This does not mean that every avenue for the escape of heat must be shut off, for heat production continues, though at a decreased rate, and hyperthermia with its exhausting influence may be induced.

There have been two deaths attributed to hyperthermia where warmed ether vapor was administered.[3] In each case there had been an operation involving the central nervous system so that the causal relationship of the anesthetic could not be determined, but it seems well to bear in mind that such an occurrence is possible. An anesthetized patient, well covered, will frequently maintain a uniform temperature. If now the only remaining avenue for the escape of heat is closed, and the patient loses the unquestioned stimulating effect of inhaling cool air, hyperthermia may occur, just as insolation occurs to some individuals on oppressive, muggy days in summer when the temperature of the air stays around 38° C. Instances have come to our attention where patients have complained greatly during the induction of anesthesia with warmed vapor because of its oppressiveness and have expressed great relief when the anesthetic was changed to an unwarmed vapor.

Taking the fall in temperature during comfortable, natural sleep as a standard, we have yet to see statistics demonstrating decreases in temperature, said to be due to the use of unwarmed anesthetic vapors, which approach the pathological.

Note has been made of the difference in the degree of the fall in temperature between male and female in the above observations. This, we know, is nothing more than a coincidence; nevertheless, we suggest that we may have here the key to the reported differences in the degree of the fall of body temperature in patients anesthetized with previously warmed ether vapor and in patients anesthetized with ether vapor which has not been so treated.

LOCAL IRRITATION AND CHEST COMPLICATIONS.

THIS IS A SUBJECT which is rather difficult to treat satisfactory because the available data, especially from the clinical side, consists of opinions and not of material which lends it self to critical analysis. The advocates of warmed vapor appear to regard it as a perfect prophylactic in all respiratory disorders incident to inhalation anesthesia. Cough and laryngeal spasm is hardly ever seen.[7] "Dryness of the throat is never complained of unless oxygen has been added." "Cold produces the so-called irritation of ether, contributing to nausea, vomiting and shock, delays the return to nutrition, disturbing the stomach by ingestion of ether-laden secretions, annoys the patient by leaving a lingering after-taste on the breath, due to impairment of the eliminative functions of the mucous membranes."[4] In contrast to this, we again call attention to the testimony of Dr. Isabella Herb, who, in her large personal experience, and in a careful study of the work of fellow anesthetists, has failed to find any such disparity as that outlined above.

Graves[8] reported a series of 4,000 consecutive

7. COBURN: Medical Record, 1913, Vol. lxxxiii, 382.
8. GRAVES: Boston Med. and Surg. Jour., 1910, Vol. clxiii, 497.

extensive operations under ether administered mostly with a paper cone, the end of which was covered with a lew layers of gauze to permit of free passage of air. This series showed 37 chest complications of all sorts, with 2 deaths, a mortality of .05 per cent. and a morbidity of .92 per cent. Risley[9] reported a series of 1,920 similar cases with 27 chest complications and 2 deaths, a morbidity of 1.4 per cent. and a mortality of .1 per cent. In each of these two series 3 cases gave definite physical signs of pulmonary tuberculosis. Munroe,[10] using the open drop method, reported 1,000 cases with 15 chest complications and 2 deaths, a morbidity of 1.5 per cent., mortality of .2 per cent. In Graves series the anesthetic was administered by students under expert supervision; in the other two series by internes. Graves further analyzed a series of 2,000 cases and found that chest complications occurred after laparotomy 10 times as often as after extra abdominal operations of the same duration, and much less commonly after pelvic operations alone than after operations higher in the abdomen. In 920 extra abdominal operations he had only 2 chest complications, one of these in a septic case, a morbidity of .21 per cent. Kronlein[11] reported 1,409 laparotomies etherized by a trained anesthetist by the open drop method, a mortality from chest complications of 0.56 per cent. Gottstein[12] found more respiratory complications following operations under local anesthesia than he did following equally extensive operations under chloroform.

In view of the disproportion in the incidence of chest complications after laparotomies and after septic cases as compared to extra-abdominal clean cases, and in view of the chest complications following operations under local anesthesia, it seems open to question whether so-called unwarmed ether, as such, can be made to assume responsibility for them.

The material available from the clinics of the advocates of warmed ether-vapor is not sufficient to permit comparison with the above, though Läwen[13] concluded that the use of warmed vapor does not prevent penumonia.

Using unwarmed ether intratracheally on dogs, Meltzer[14] did not notice unusual evidences of irritation. McCarty and Davis[1] found no difference in the quantity of salvia and mucus secreted by dogs anesthetized with warmed and with unwarmed ether vapor, nor did they find appreciable differences in the reaction of the respiratory mucus membrane as evidenced by changes visible to the naked eye, or by the course of the convalescence.

There is no proof that the preliminary warming of ether vapor decreases respiratory complications, or that failure to warm the vapor increases them; there is evidence that the procedure does not prevent postanesthetic pneumonia.

SUMMARY AND CONCLUSION.

THERE IS AS YET no proof that warmed air-ether-vapor gives a greater margin of safety in anesthesia than the unwarmed vapor; it may be distinctly dangerous by aiding in the production of hyperthermia.

2. The assertion that preliminary warming of the vapor decreases pulmonary irritation is open to question.

3. The warmed vapors do not always add to the comfort of the patient, they may be distinctly uncomfortable.

4. Gram for gram of ether, there is no difference in the efficiency or toxicity of warmed and unwarmed vapor.

5. From the standpoint of simplicity and general adaptability, the unwarmed vapor is superior.

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9. RISLEY: See Graves.
10. MUNROE: See Graves.
11. KRONLEIN: See Graves.
12. GOTTSTEIN: Archiv. f. Klin. Chir., 1898, Vol. lvii, 409.
13. LAWEN: Muench. Med. Woch., 1911, Vol. lviii, 2097.
14. MELTZER: Medical Record, 1910, Vol. lxxvii, 477.
15. GWATHMEY: Medical Record, 1904, Vol. lxvi, 816.

THE FACT THAT the warming of anesthetics is still a mooted question lead Paul Cassidy, of Cincinnati, Ohio, to study the problem anew both clinically and experimentally with regard to nitrous oxid-oxygen anesthesia. During the Joint Meeting of the Interstate Association of Anesthetists with the Mississippi Valley Medical Association in Toledo, Ohio, October 9-11, 1917, he reported on his results and later elaborated them in the Anesthesia Supplement of the American Journal of Surgery, April, 1918. Cassidy is convinced of the necessity and advisability of warming nitrous oxid-oxygen even for short dental operations.

It is a fundamental physical law that the transformation of a solid into the liquid state, of a liquid into a gas, deprives the surrounding media of a definite number of heat units, and, hence, brings about a lowered temperature therein.

The temperature of any substance is dependent upon the mode of motion of the particles involved. The particles of a liquified substance are not able to move with the same freedom as when that same substance is in its natural, gaseous state. Hence any change from a liquid to a gas involves a greater freedom of motion of these particles, which every change in their mode of motion, in consequence, absorbs heat units from the surrounding media. We can, therefore say, in unscientific language, that cold is developed in all things immediately surrounding any substance in the process of being changed from a liquid into a gas.

To assert that liquified nitrous oxid is any exception to this rule is scientifically absurd. Any experiments that have been performed, in good faith, which seem to indicate this exception, have not been properly conducted, and are, in consequence, of no real significance.

Having been a believer in warmed vapor for anesthetic purposes for fifteen years, I have been much interested always when the assertion has been made that nitrous oxid in particular does not require warming, as, indeed, it is always of the temperature of the atmosphere by which it is surrounded. A report of five hundred cases, with the varying results obtained in the use of warmed and unwarmed nitrous oxid administered for short duration anesthesia was made by me one year ago. The statistics of one man are seldom satisfactory to others, and I expected my findings to follow this course. My deductions, however, did call forth one assertion which I have felt it was to the interest of all finally to disprove. I had said that nitrous oxid flows into the anesthetizer at a temperature of anywhere from 40° to 60° Fahrenheit scale. This was absolutely denied. To prove my deduction entirely a correct one, I decided to construct an apparatus that would permit of the accurate reading of varying temperatures within a nitrous oxid anesthetizer. The result has only confirmed me in my belief, and I submit it at least to indicate that there is a considerable danger to all patients anesthetized, for even a short time, with unwarmed, or inadequately, warmed, nitrous oxid vapor changed directly from the liquid state.

It may seem unnecessary that any note of warming at this late day should be uttered against the administration of unwarmed nitrous oxid. You have all of you administered this gas through heated and unheated anesthetizers. Some have continued, unthinkingly, to use the warming devices for no other reason than that it was considered the proper thing to do. Others, more observant of results, have discarded the warming attachments because the heated and the non-heated vapors apparently acted in about the same fashion. And they did, for the very simple reason that the heating devices attached to most of the anesthetizers on the market are wholly unable to heat the gases passing through them to any appreciable extent. The heating chambers are so small and the heating elements of so little power that whether they are employed or not, the gases pass through them at practically the same temperature. You, therefore, who have abandoned your warming attachments on the assumption that all warming is unnecessary, have done so upon a wrong surmise. Inadequately warmed vapor is little better for anesthetic purposes than unwarmed vapor. This fact will hardly justify, however, a refusal properly to warm the gases when this result can and should be obtained.

It is a fact that in few, if any of the machines that have been presented for our use, will the gases passing through them, be raised to the proper temperature for anesthesia. If it is advisable to inject liquids for regional anesthesia at a temperature approximately that of the body, it is, at least, as necessary to administer gaseous anesthetics at about the same temperature when possible. I am confident that the very reason for the considerable success of the early users of nitrous oxid, even though their equipment was otherwise to be condemned, lies in the fact that the anesthetic was delivered to the patient at about the body temperature, and with no preexistence in the liquid state.

Properly to understand that these experiments were not conducted in a haphazard fashion, relying principally upon guess-work for results, as has been done in the past, a description of the apparatus employed will be necessary.

EXPERIMENTAL APPARATUS.

RECOGNIZING THAT A thermometer placed at the exit of an anesthetizer could not accurately register varying temperatures; that it would be impossible to place one within a rubber bag where the differences in temperature could be read, I decided upon the construction of a metal bag, which, with a glass window through which to observe the thermometer, would permit of the immediate reading of all changes in temperature within the chamber, should any occur. This bag was built, of heavy copper plate, in elliptical form, with two flat sides. The capacity of the tank is about five gallons. An eight-inch brass union, so-called, is soldered into the bottom, and to this was attached the inlet tubing. At the opposite end of the bag were soldered two quarter-inch unions, one to be used for the outlet and the other as an attachment for a safety-valve of the double acting type. From one flat side there extended into the bag a copper can measuring three inches in length and the same in diameter.

Within this was placed the electric heating element, after all joints were securely soldered to prevent air leakage into the larger can. Immediately above the opening into this heating chamber was placed a brass pipe which leads to a pressure guage, which is very delicate and was made for this purpose specially, registering, accurately, from naught, or rather from atmospheric pressure, up to an added pressure of six ounces.

Into the other flat side of the bag was a threaded ring, three inches in diameter. Upon this was screwed a brass cap, in the center of which is a glass window, two inches in diameter.

Through the exit in the top was passed a registered thermometer, reading from 32° to 200° Fahrenheit scale. This was attached firmly by brass wire soldered to the top of the bag. (See illustrations.)

I trust that this description of the apparatus will at least be sufficiently comprehensive to indicate that I have spared no pains to make the results obtained certain and conclusive.

Through a rubber tube three feet in length I passed nitrous oxid from a 1,250 gallon cylinder into the unheated bag at a pressure of 2 ounces in an atmosphere of 80° temperature, and at the end of 2 minutes the registration of the thermometer had not changed. In 4 minutes, however, it had fallen 5 degrees.

Later, when the material of the apparatus had again assumed room temperature, nitrous oxid was again passed through at 2 ounces pressure for 20 minutes. When the experiment was begun the thermometer registered 81°; at the expiration of the 20 minutes it registered 58°, a drop of 22°, or a drop of a little more than 1° a minute for the entire period.

After having turned on the electric current in the warming-chamber until the temperature stood at 130°, nitrous oxid at 2 ounces pressure was passed into the bag for 3 minutes. A drop in temperature of 1° was noted.

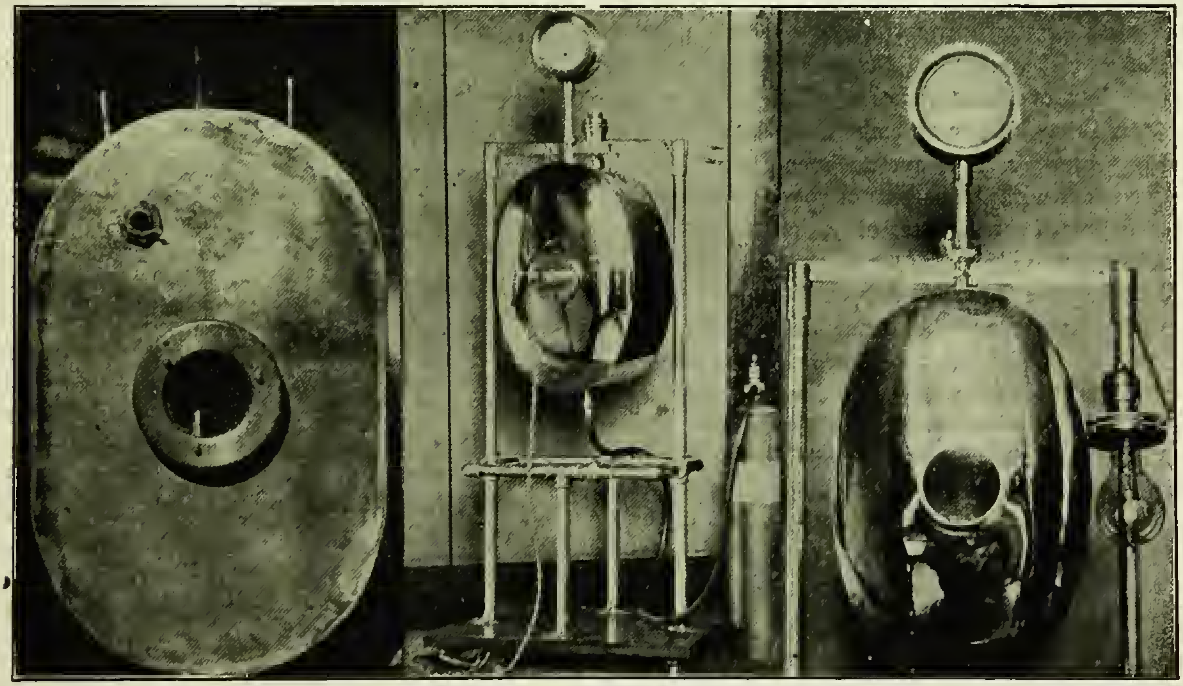
With the thermometer registering 130°, nitrous oxid, at a pressure of 2 ounces, was passed into the bag for 10 minutes, and a difference in temperature of 8°, a little less than 1° a minute average, was observed.

That gases compressed greatly, but not into liquid form, assume the temperature of the surrounding atmosphere unless placed in containers of non-heat-conducting material, is a recognized physical fact. For this reason, oxygen in cylinders which have been within doors sufficiently long may be administered in very cold weather, over long periods, with impunity. This I proved by an experiment.

In an atmosphere of 76°, into the unheated apparatus was passed oxygen for 3 minutes, with no resultant change in the position of the mercury in the thermometer.

At the same pressure and room temperature oxygen was flowed into the unheated chamber for 10 minutes without any change. After having passed oxygen into the unheated bag for 25 minutes without any drop in temperature, I felt the indication conclusive.

On passing the oxygen through the apparatus when the thermometter showed a temperature of 125° for 15 minutes, a drop of 2° was shown. This resulted, I presume, from the gas passing into the chamber at a temperature of 76°, depriving its superheated surroundings of some heat units and in this manner reducing the temperature of the bag slightly.



Figs. 1, 2 and 3. Illustrating the experimental apparatus used by Cassidy in his study of warmed and unwarmed nitrous oxid.

You may note that I was much more liberal in my experiments with oxygen than in those with nitrous oxid. The former I can purchase very cheaply. Not being attached to any public institution, where experimental material seems to cost little or nothing, I cannot afford to be entirely wasteful with nitrous oxid.

EXPERIMENTAL CONCLUSIONS.

AS A RESULT of these experiments, I would conclude that in very warm weather, for anesthesias of no longer duration than 2 minutes, unwarmed nitrous oxid is equally as good as the heated gas; that in anesthesias lasting over 2 minutes the use of unwarmed nitrous oxid becomes progessively more dangerous with every added minute; that in an atmosphere of a temperature of not more than 70° even the 2-minute period is too lengthy. I have not been able to prove this last assertion, because of the fact that as yet I have not had an atmosphere of 70° in which to make it.

Whenever we heat gases by electric current, we do so by radiated heat. It is a fact that to heat by radiation, proportionately large surfaces coming into contact with the circulating gas or liquid, whatever that gas or combination of gases or liquid may be, are an essential. A gallon vessel of water placed above an open flame coming into contact with the bottom of the vessel through an opening of one-quarter of an inch in diameter would never boil, no matter what the intensity of the heat of the flame. In about the same relative proportions the anesthetic machines which have been devised for us have warming chambers, from the walls of which the flowing gases are heated by radiation, inadequately small.

My earnest plea, therefore, will be that you insist upon being provided with anesthetizers having heating chambers of a sufficient size and a heating element equal to the task of raising the temperature of nitrous oxid, as we use it, to the proper point to make its employment as wholly safe as we can wish and as its great merits as an anesthetic agent so richly deserve.

CLINICAL OBSERVATIONS.

TO POUR INTO THE sensitive respiratory apparatus gaseous matter of a temperature from thirty to fifty degrees below normal body temperature is a physiological crime. The short duration of the anesthesia lessens not one bit the evil effects. The first sudden shock is the prime consideration. A patient will stand a warm gas, with its temperature gradually decreased, over a long period of anesthesia with much less shock than where cold vapor is given even for a short period. Nature in all things and state resents violent change and demands in every instance full reckoning.

As a man can be safely carried in smoothly running elevators from thirty-story buildings to street level without shock, when he would be bruised beyond recognition if dropped from a window on the sixth floor, so too is man safer if carried from normal consciousness into prolonged anesthesia, always an unnatural state, with the least possible degree of sudden change, than he would be if suddenly carried from consciousness into anesthesia of very much less duration.

It is only by an exact study of a large number of cases that results of clinical experiment prove of value.

In order to indicate to others my own experience covering a very large number of cases, I set aside the month of June, in which to acquire statistics. I decided that my first patient would be given warmed gases and the next gases administered at room temperature. The third, the warm, and so on, rotating throughout the month between the warmed and the cooler gases. In this connection I will further explain, that, although I speak of cold gases, the adjective does not exactly fit conditions, as I have a fifty-gallon tank in which each vapor takes up many units of heat before passing into use. With the single exception of low-toned individuals who presented, to whom I invariably give warmed gases, I followed my program throughout June with the result that more than ever I was convinced of the fallacy that cold gases are in every way as safe for short-period anesthesia as are those warmed to a point approximating body temperature.

The following facts, however, should prove of interest: The patients range through the whole gamut of life, embracing human existence in all its degrees, from the three years of age child, to the old man of seventy-two; from the indigent pauper to the well-nourished and intellectual, an even five hundred of them. Of these, one hundred and ninety-two were given unwarmed nitrous oxid and oxygen, and the balance of three hundred and eight the artificially warmed gases.

Resulting slight nausea was almost six to one greater following the use of the cold gases. To procure deep anesthesia, one-third more oxygen could be given with warmed gases than with cold, with the resultant better respiratory action and more satisfactory pulse-rate.

Struggling during induction and following anesthesia, always a difficult matter to put down upon paper in statistical form, was seemingly less with the warmed vapor than with the cold. Complaints of head pains, all of which were carefully tabulated, were sixteen less from the three hundred and eight than from the one hundred and ninety-two, in spite of the fact that the former number embraced to my knowledge eleven pregnant women, all of the low-toned men and women and all those of any considerable age.

Hallucinations, of various sorts, were more marked; or shall I say better remembered, following the administration of warmed gases than with the cold. I account for this phenomenon by the very evident fact that the return from anesthesia to full consciousness is more gradually accomplished following the use of the warmed gases, and in this way, dreams are neither rudely shattered nor abruptly shocked from memory.

I have always made it my practice to ignore time as a consideration in anesthesia, and so I found it almost impossible to change my habit in this regard. In those cases where I remembered to keep a record of the length of the period of induction the cold gases invariably produced anesthesia in a shorter time than the warmed. This was due to the lessened amount of oxygen I was able to utilize with the cold vapors. At first thought this shorter period of induction would seem to indicate greater safety. Recall, however, that the man jumping from the roof of a house will always reach the ground in less time than if the elevator were put to use.

The average time in the operating room of the five hundred patients was a little less than fourteen minutes; the average time in the operating room of those given cold gases was between sixteen and seventeen minutes. In the practice of any busy man the more than two minutes difference, multiplied many times during the month is no slight consideration.

Records arranged by anyone are seldom wholly satisfactory to others and I feel mine are no exception to this rule. However, from a right experience of more than thirteen years, ten of which have been devoted exclusively to the administration of anesthetics, nitrous oxid and oxygen having had a very large place in my practice, I think I can speak with some degree of authority when I say that it is at least as necessary to administer warmed vapors for short period as it is for prolonged anesthesia. Those who doubt the wisdom of warming nitrous oxid and oxygen under any circumstances, have but to study the results of the experiments of Gwathmey to be convinced of the wisdom of such procedure.

Little has been said, and less written, about the disadvantages of cold vapor for short-period anesthesia, but the element of sudden change remains, no matter what the duration of the anesthesia may be.

Those who rely solely on the breathing for the heating of the gases admit by this very fact that warmed vapors are the better to employ and yet contend that the make-shift is sufficient to warm the gases. The rebreathing of a sufficient quantity of nitrous oxid and oxygen to produce anesthesia in normal, average weather, will raise the vapor remaining in the bag after anesthesia is complete between eight and twelve degrees Fahrenheit. This can be proven to the satisfaction of any one by means of an easily devised apparatus. While even a twelve degree rise in temperature is of advantage, there is no possible excuse for satisfaction when a fifty degree rise is as available by other means.

The proof of all contentions lies in several results obtained and I maintain that, in my experience, warmed nitrous oxid and oxygen anesthesia is more satisfactory, and in consequence safer, under any and all circumstances.

THE PHYSIO-PATHOLOGY OF ETHYL CHLORID . PREVIOUS INVESTIGATION . METHODS OF EXPERIMENTAL RESEARCH IN THE PRESENT STUDY . EFFECTS OF INCREASING CONCENTRATIONS OF ETHYL CHLORID ON INTACT AND VAGOTOMIZED DOGS . FACTORS CONTRIBUTING TO THE DIFFERENCE IN RESULTS . SYNCOPE AND ETHYL CHLORID . THE EFFECT OF ETHYL CHLORID ON THE HEART . EFFECT ON THE ARTERIES . EFFECTS ON RESPIRATION . CONCLUSIONS DRAWN FROM THE VARIOUS PHYSIO-PATHOLOGICAL STUDIES.

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ETHYL CHLORID AS an anesthetic came into its own during the late World War hence it is pertinent to have the following exhaustive review and personal study of the physiopathology of ethyl chlorid by E. H. Embley, of Melbourne, Australia, for publication. The paper was originally presented by proxy before the Interstate Association of Anesthetists during the Fourth Annual Meeting, in Indianapolis, September 25-27, 1918. Its publication in the Year-Book will be appreciated by those who wished to be thoroughly versed in the fundamentals of the anesthetics they use.

As far back as the year 1847, ethyl chlorid was found by Fleurens to possess the properties of a general anesthetic agent, and in consequence was used by Heyfelder, in the following year, as a general anesthetic, in a few operations. Its value was further investigated by Benj. Ward Richardson[1] in 1867, and by the Glasgow Committee of the British Medical Association[2] who reported in 1879 and 1880. These various reports were unpromising. Chiefly in consequence of this it remained without further notice for some years until attention was again drawn to it by the report of some Swiss dentists who had observed a condition of general anesthesia to supervene during the use of this substance for freezing in dental operations. Thereupon in the year 1898, Lotheisen[3] entered upon a career of success with it as a general anesthetic. Hacker and Ludwig[4] also investigated it about this time. Lotheisen's success launched it into general use and its employment rapidly spread. Clinical reports recording results appeared in rapid succession. Among the pioneers in the clinical field appear the names of Ware in the years 1901 and Luke, Bloomfield and Hatch in 1903, Gaudiani, Flemming, Carter Braine, Daniells, Hewitt, DePrenderville, Chaldecott and Stephenson in 1904, Hilliard and McCardie in 1905, and McCardie and Knight in 1906.

PREVIOUS INVESTIGATION.

IN THE RESEARCH FIELD its pharmacology was investigated by Cole,[5] of Cambridge, in 1903, Webster,[6] of Winnipeg, in 1906, Embley,[7] of Melbourne (the present writer) in 1906, Camus and Nicloux[8], in 1908, and Fielden,[9] of Belfast, in 1912.

1. Richardson, B. W.: Medical Times and Gazette, December 28, 1867.
2. Glasgow Committee: British Medical Journal, 1879 and 1880.
3. Lotheisen: Archives f. Klin. Chirurgie, Bd. 91, Ht. 65, 1910.
4. Hacker and Ludwig: Beitrage z. Klin. Chirurgie, Vol. 19, No. 3.
5. Cole: Proc. Journal of Physiology, June 15, 1903.
6. Webster: Biochemical Journal, 1906.
7. Embley, E. H.: Proc. Royal Society, London, Series B, 1906.
8. Camus and Nicloux: Jour. de Physiologie et Pathologie, Tome 10, 1908.
9. Fielden: Thesis, Belfast, 1912.

A rapidly growing confidence in the usefulness and relative safety of the agent is to be observed in the clinical reports as year after year its employment spread.

All research workers were unanimous in finding that the higher concentrations of the vapor of ethyl chlorid in the inspired air caused a fall of blood pressure. Cole,[5] Webster[6] and Fielden[9] found this solely due to weakening of the heart's contractility. They do not appear to have observed any instance of sudden or syncopal fall of blood pressure such as I[7] have shown experimentally to occur, and which has not infrequently been observed clinically. Cole in fact inferred that the cardiac vagi weres paralyzed by ethyl chlorid. Webster and Fielden both deny Cole's inference, although they furnish very little evidence in support of their attitude. *It seems to me that Cole was right in his finding that the cardiac vagi were rendered irresponsive to stimuli, but that he was in error in attributing it to the ethyl chlorid when in reality it was due to the mode of preparation as I shall endeavor to confirm in the subsequent pages.* What evidence there is discoverable of the function integrity of the cardiac vagi, in an analysis of the reports of the experiments of both Webster and Fielden, indicates no wide discrepancy from that obtaining in Cole's. In accordance with such inferences, Cole, Webster and Fielden regard failure of the respiration as the source of danger in the narcosis of ethyl chlorid. *As regards the condition of the arterial system both Cole and Webster found the arteries passive, whilst Fielden found them contracted except in the later stages of narcosis when the blood pressure was low. My results show arteriolar relaxation as a local effect, but at the same time a central vasomotor stimulation vicariously affecting the constrictor or the dilator mechanisms, the algebraic sum of which two factors is a minus quantity—a fall of arterial blood pressure—when the incidence of the stimulus is upon the dilator mechanism but an uncertain quantity when upon the constrictor. In prolonged administration, all findings of course agree as to the gradual onsetting of vasomotor paralysis. Fielden found that the administration of oxygen with the ethyl chlorid increased its relative safety, and that on the other hand the addition of carbon dioxid instead of oxygen had the opposite result. Camus and Nicloux*[7] *emphasize the fact that the danger from ethyl chlorid (like that from any of the other anesthetic agents) is not in the actual total quantity of ethyl chlorid absorbed, but in the high concentration of the substance in the arterial blood at the time.* They found that a concentration of 25 mg. per 100 cc. of arterial blood is that necessary for the induction of anesthesia. They confirm my results[7] as to the absorbtion co-efficient of blood for ethyl chlorid. Haslebacher[10] found that only after prolonged administration were slight pathological changes observed in the kidneys.

METHODS OF EXPERIMENTAL RESEARCH.

THROUGHOUT THE EXPERIMENTAL work, from which the data given in this paper were derived, dogs were employed, in each case adequately morphinized by preliminary injection. This was done for two reasons:

(1) The humane one of preventing suffering during the operative preparation.

(2) The preservation of function of the vagus nerves, which otherwise becomes depressed by pain and fright of the operative preparation, or by the administration of ether or chloroform for anesthesia during preparation.

Although morphin so used is apt to depress respiration so that its rhythm in some instances becomes markedly slow,[11] it, on the other hand preserves the excitability of the central mechanism of the cardiac vagi so that this very important factor in relation to the circulation remains intact, hence the occurrence of cardiac inhibition and consequent syncope in dogs so prepared.

The tracings and experimental results furnished in this paper differ so greatly from those of the other pharmacological workers above mentioned in this matter of cardiac inhibition that I am compelled to assume that it is in the prelimi-

10. Haslebacher: Quoted from McCardie, British Medical Journal, March 17, 1906.

11. Embley, E. H.: Australian Medical Journal, August 17, 1912.

nary preparation and conservation of integrity of function of the cardiac vagi wherein the difference rests.

If a dog be inadequately morphinized or not morphinized at all during the preliminary surgical procedure, the fright or the pain of the operative preparation and the fright of the administration of the ethyl chlorid in the beginning of the experiment, together, depress the excitability of the vagi to such a degree that the ethyl chlorid is unable to exalt it even to the extent of slowing the heart rhythm, much less to that of arresting the heart. The same result happens if chloroform[12] or ether[13] be used for anesthesia in performing the operative preparation.

In Table I are given the results of administering increasing concentrations of ethyl chlorid to intact dogs. Respiratory failure in these instances and in all others investigated, had no part in the causation of the fall in arterial blood pressure or arrest of the heart. There is also shown a definite relation between the fall in arterial blood pressure and the slowing of the rate or arrest of the heart.

Table II is given to show the effects of increasing concentrations of ethyl chlorid when administered to dogs previously vagotomized. Compared with the results of Table 1 (intact animal) the difference in effect upon the arterial blood pressure induced by similar concentrations is very striking. On the vagotomized dog for instance, the administration of 30 per cent. concentration produced approximately the same extent of fall as did 10 per cent. in the intact animal.

TABLE I. (INTACT ANIMAL.)

Dose	Vagus inhibition of heart	Respiration	Fall of blood pressure in mm. Hg.	Heart rate per minute	Corneal reflex abolished
Per cent.					
3.5	None in 15′	Unaffected in 15′	None in 15′	Unaffected in 15′	None in 15′
7	Slowing only	Unaffected in 13′	127 to 80 in 13′	90 to 69 in 13′	Gone in 2′ 4″
10	None	Slowing	Unaffected in 14′	Unaffected in 14′	" 1′ 45″
10	Slowing only	Little irregular	198 to 50 in 14′ 30″	65 to 30 in 14′ 30″	" 1′ 30″
10	Slowing down to arrest	Ceased as heart ceased	100 to 0 in 2′ 15″	60 to 0 in 2′ 15″	" 1′ 30″
15	None	Unimpaired	Unaffected in 12′	Unaffected in 12′	" 1′ 45″
15	Slowing down to arrest	Ceased twice for 2′ each	120 to 8	Slowing to stop, 74 to 0	" 1′ 30″
18.5	" "	Ceased in 8′ 10″	120 to 0 in 8′ 25″	65 to 0 in 8′ 25″	" 1′ 15″
18.5	Slowing intermittently	Very slow	Unaffected in 14′	Intermittent rise and fall	" 1′ 15″
20	" "	"	Falling after one inspiration, rising before the next	" "	" 1′ 30″
20	None	"	78 to 70 in 13′	Unaffected in 13′	" 1′ 45″
20	"	Unimpaired	Unaffected in 12′	Unaffected in 12′	" 1′ 10″
20	Slowing only	"	124 to 90 in 7′ 30″	90 to 40 in 7′ 30″	" 1′ 0″
20	Slowing	Ceased in 5′ 35″	135 to 56	68 to 24	" 1′ 15″
30	Great slowing	Failed in 1′ 15″	120 to 24 in 1′ 15″	80 to 10 in 1′ 15″	" 0′ 45″
30	Slowing intermittently	Very intermittent	116 to 18 in 8′ 40″	84 to 14 in 8′ 40″	" 1′ 15″
30	Slowing down to arrest	Ceased at 0 blood-pressure	100 to 10 in 3′ 20″	86 to 0 in 3′ 20″	" 0′ 35″
30	None	Unimpaired	102 to 38 in 7′	Unaffected	" 1′ 10″
30	Great slowing	Failed in 2′ 45″	112 to 50 in 2′ 45″	90 to 10 in 2′ 45″	" 0′ 50″
30	Arrested	Failed in 3′ 14″	124 to 0	80 to 0	" 0′ 55″
30	Great slowing	Artificial respiration	104 to 30 in 4′ 30″	88 to 16 in 4′ 30″	" 0′ 40″

EFFECTS OF INCREASING CONCENTRATIONS OF ETHYL CHLORID ON INTACT AND VAGOTOMIZED DOGS.

WITH REGARD TO the arterial blood pressure, it was found that concentrations of 10 per cent. and upwards of ethyl chlorid promptly started it to fall, the steepness of which increased directly with the concentration, subject however to individual variation. With lower concentrations than 10 per cent. the onset of the fall in pressure was proportionately slower.

FACTORS CONTRIBUTING TO THE DIFFERENCE IN RESULTS.

THE FACTORS CONTRIBUTING to this difference in result—myocardial depression being common—for equal concentrations are:

A. Those contributing to the fall of arterial blood pressure in the intact animal.

(1) Slowing of the rate or arrest of the heart from cardiac inhibition.

12. EMBLEY, E. H.: British Medical Journal, April 5, 12 and 19, 1902.
13. EMBLEY, E. H.: Biochemical Journal, Liverpool, Vol., 5, 1910.

(2) Vasodilation accompanying the cardiac inhibition.

B. Those contributing to the maintenance of the arterial blood pressure in the vagotomized animal.

(1) Acceleration of the heart rate as a result of vagotomy.

(2) Vasoconstriction accompanying the cardiac acceleration.

often as slow in rhythm as in the average vagotomized animal.

It will therefore be seen that the diminution in the heart rate together with the coordinate vasodilation is of first importance in occasioning the sudden great fall in arterial blood pressure and arrest of the heart in the administration of ethyl chlorid (that is) of causing syncope.

In none of the experiments in which syncopal falls of arterial blood pressure occurred was any other cause discovered than cardiac inhibition. In no instance was any semblance of ventricular fibrillation observed.

TABLE II. (VAGOTOMIZED DOG.)

Dose	Time	Heart rate	Fall of blood pressure in mm. Hg.
Per cent.			
10	14′	No change	No fall in blood pressure
15	12′	No change	No fall in blood pressure
20	12′	No change	No fall in blood pressure
20	13′	No change	Fell from 78 to 70 mm. Hg.
30	7′	No change	Fell from 102 to 38 mm. Hg.

(3) Diminished respiratory intake owing to the slow respiratory rhythm of vagotomy.

(A) Slowing down of the heart rate tends to lower the arterial blood pressure by reason both of the diminished output, and of the increased concentration of ethyl chlorid in the arterial blood owing to the increased uptake resulting from the diminished velocity of the pulmonary blood stream. This, however, of itself could not induce so marked a fall were it not that vasodilation sets in co-ordinately with cardiac inhibition.

(B) Acceleration of the heart rate together with coordinate vasoconstriction have obviously the contrary effect to that just described—an increased cardiac output and a lowered concentration of ethyl chlorid in the arterial blood, sustaining the blood pressure.

The diminished respiratory rate of the vagotomized animal affects the blood pressure only when the rate is very slow. It is not a material factor, however, in maintaining the arterial blood pressure in the vagotomized animal as shown by the fact that in several instances in which the ethyl chlorid was administered by artificial respiration the pressure was maintained quite as well as in those to which the ethyl chlorid was administered by natural respiration. Moreover, in the experiments with the intact animal in which the blood pressure rapidly fell on the administration of ethyl chlorid, the respiration was

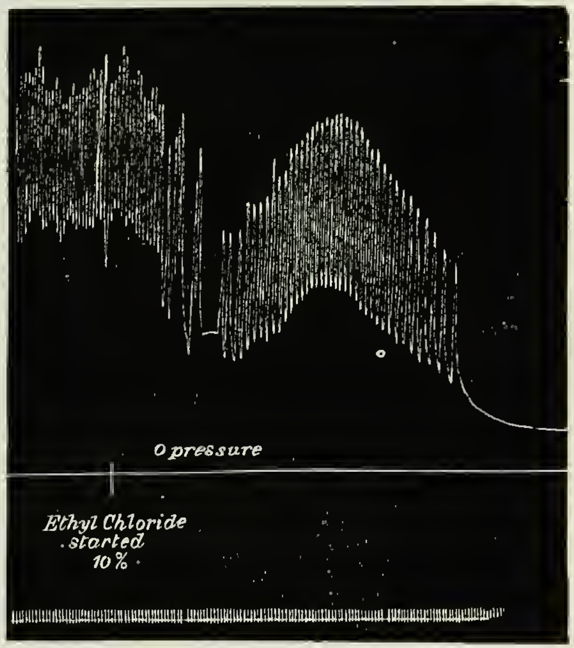


Fig. 1. (Original Size)—Vagus inhibition. Dog-weight, 4.2 kilograms. Morphin 0.2 gram. Blood pressure tracing. Air containing 10 per cent. of ethyl chlorid vapor administered by artificial respiration. Blood pressure at starting 83 mm., after 1′ 45″ administration the blood pressure fell to 10 mm. from vagus inhibition. Recovery.

SYNCOPE OF ETHYL CHLORID.

ARREST OF THE HEART during the administration of ethyl chlorid when occurring more or less suddenly, therefore, is due to vagus inhibition accompanied by arteriolar dilation. In such cases of syncope the heart promptly recommences to beat upon vagotomy, 3 records respiration.

Cardiac inhibition as induced by ethyl chlorid is not reflex from afferent impulses arising in the respiratory tract but is due to the direct effect of the ethyl chlorid upon the central mechanism in the medulla. This is shown in Fig. 2. In the experiment from which this was obtained the

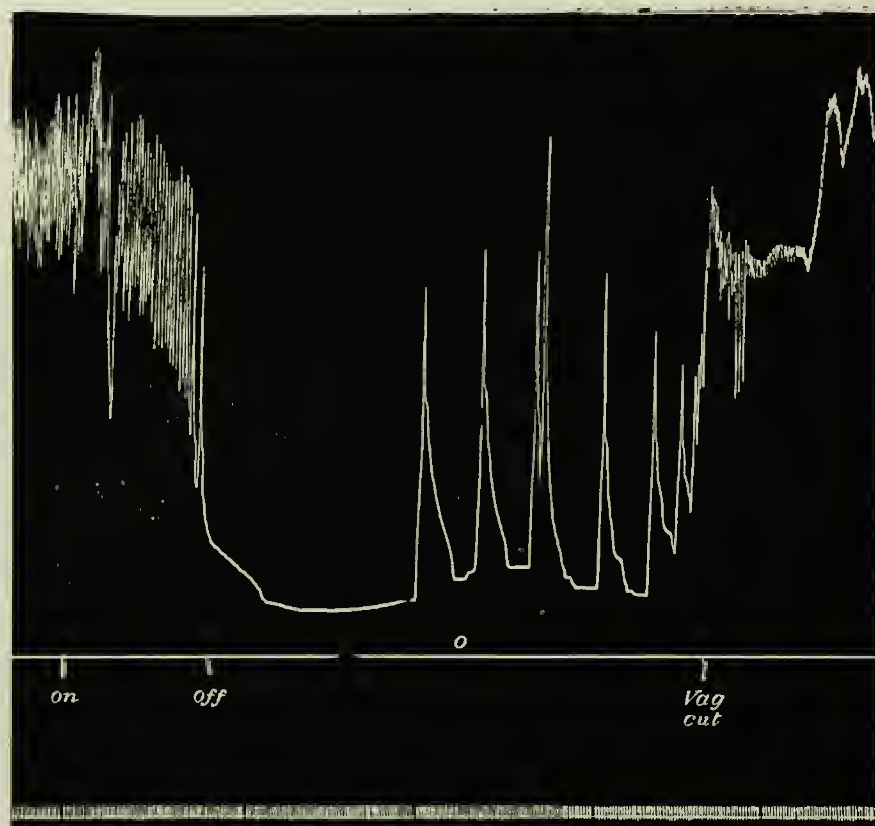


Fig. 2. (Original size)—Vagus inhibition from central stimulation. Dog-weight 9.4 kilograms. Morphin 0.4 gram. Curare 0.02 gram. Artificial respiration. Artificial arterial brain circulation prepared as in experiment for Fig. 9, but with the vagi intact. Blood pressure figure. Artificially circulating blood contained ethyl chlorid equal to 30 per cent. of the vapor. Blood pressure at starting 126 mm. Artificial circulation started at *on* and continued for 49″, ceasing at *off*. Blood pressure fell to 10 mm. The heart ceased from vagus inhibition. Recovery by vagotomy.

at the usual accelerated rate. In no instance did syncope occur in an animal previously vagotomized or adequately atropinized. Such syncope is in all respects similar to that occasioned by chloroform.[12] Figs. 1, 2 and 3 are arterial blood pressure tracings showing syncopal fall of blood pressure and arrest of the heart by inhibition. Fig. 2 also shows the effect of vagotomy, and Fig. ethyl chlorid was administered by an artificial carotid circulation, so that the vapor did not come in contact with the respiratory tract.

In comparing the cases of chloroform syncope occurring in my experimental work in chloroform,[12] I find that 2.5 per cent. chloroform vapor produces approximately the same degree of cardiac inhibition as 10 per cent. ethyl chlorid. *The* *propensity of ethyl chlorid to exalt the excitability of the vagus mechanism, unlike that of chloroform is not readily depressed, since inhibition can be induced, in dogs, again and again after each recovery.*

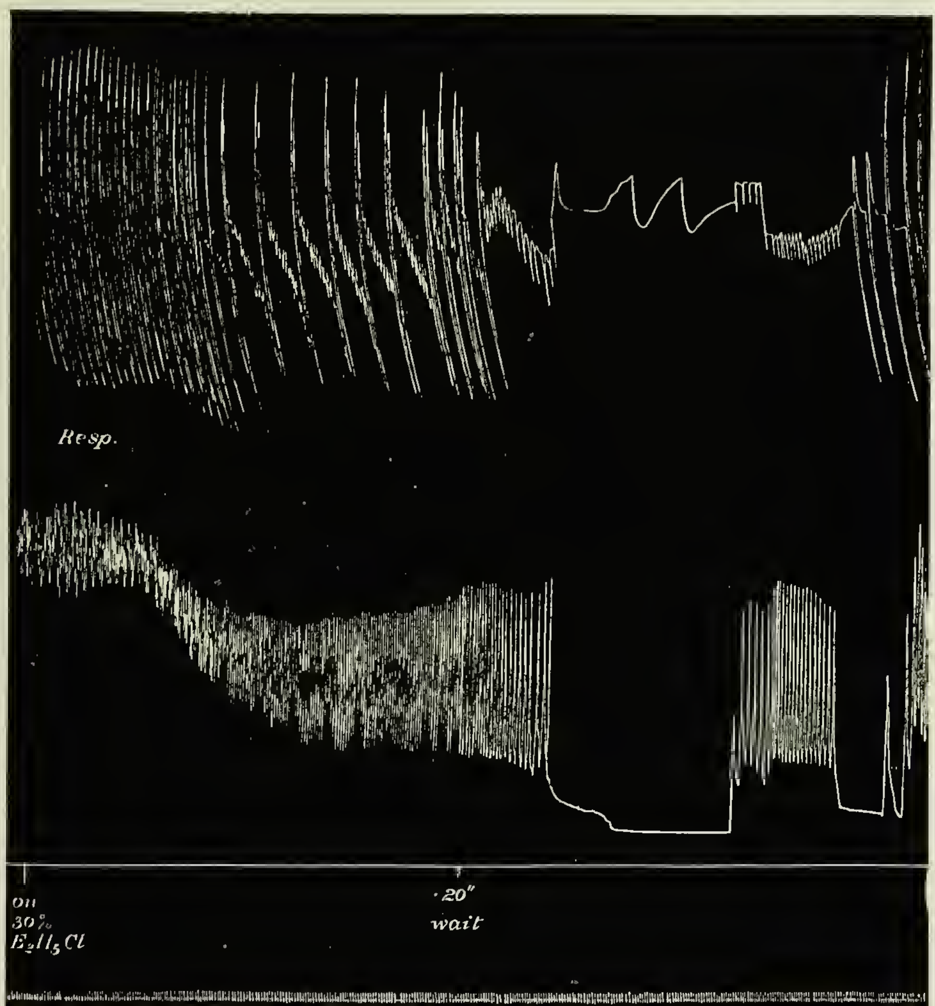


Fig. 3. (4-5 Size of original)—Interdependence of respiration and blood pressure. Dog-weight 7.8 kilograms. Morphin 0.3 grams. Respiration and blood pressure figure. Air containing 30 per cent. ethyl chlorid vapor started at *on* and administered continuously. Blood pressure at starting 103 mm. Hg. In 3′ 54″ the blood pressure fell to 10 mm. The respiration quickened after the commencement of the administration and slowed with the onset of heart slowing and ceased in 3′ 14″ with blood pressure 35.5 mm. Hg.

THE EFFECT OF ETHYL CHLORID ON THE HEART.

THIS WAS INVESTIGATED by administering ethyl chlorid in increasing concentrations to the heart lung preparation by artificial respiration. The heart thus *in situ,* freed from vagus vasomotor and respiratory influences circulates its own blood. Figs. 4, 5, 6 and 7 are arterial blood pressure records taken by this method, showing the results following the administration of 10, 15, 20 and 30 per cent. of ethyl chlorid respectively.

It will be observed that the steepness of the fall of arterial blood pressure, in our records, increased rapidly with the increasing concentrations and that the rate of the heart beats remained unaltered during the fall excepting when the pressure was low, it slowed down.

Comparative figures show that in the average the blood pressure 14 mm. Hg.; 20 per cent. caused a fall of 30 mm. Hg.; and 30 per cent. lowered the blood pressure 85 mm. Hg. Con-

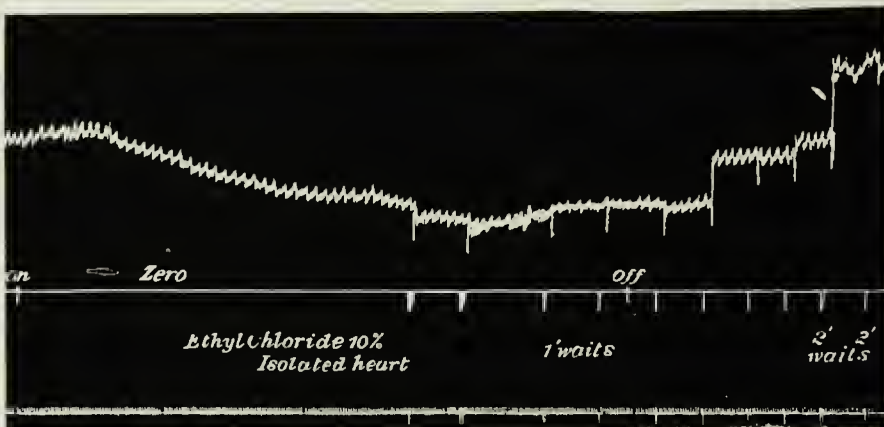


Fig. 4. (3-4 Size of original)—Isolated heart. Recovery. Dog-weight 8 kilograms. Morphin 0.3 gram and ether for anesthesia in preparation. Common trunk of the right carotid and subclavin arteries ligatured. The left carotid used for the monometer and the aorta tide just beyond the left subclavian. The left subclavian artery is thus left open to carry the circulation. Its ascending branches and the vertebral arteries are then ligatured. Vagi cut. Artificial respiration. Blood pressure tracing. Blood pressure at starting 92 mm. Hg., 10 per cent. ethyl chlorid vapor in the inspired air at starting *on* continued for 8′ 15″ and stopped at *off*. The blood pressure fell to 58 mm. The blood pressure rose to 104 mm. in 9′ 35″ after administration ceased.

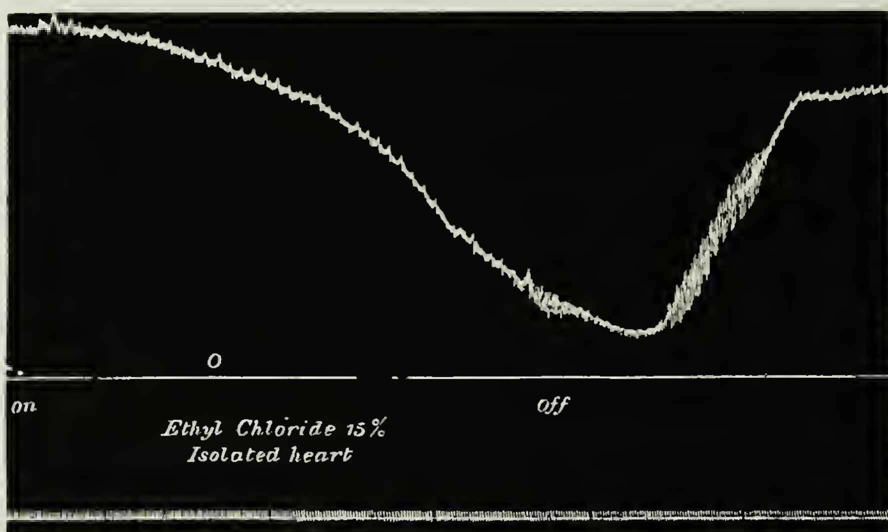


Fig. 5. (3-4 Size of original)—Isolated heart. Recovery. Dog-weight 8.5 kilograms. Morphin 0.35 gram and ether for preparation as for experiment in Fig. 1. Blood pressure 158 mm. Hg. at starting. Fifteen per cent. ethyl chlorid vapor in the air respired started at *on* and continued for 3′ 12″ and stopped at *off*. Blood pressure fell to 63 mm. Hg. In 2′ 12″ the blood pressure had returned to 139 mm.

the administration of 10 per cent. ethyl chlorid in each 30 seconds lowered the blood pressure 2 mm. Hg.; 15 per cent. in the same time lowered trasting these results with that produced by chloroform,[11] 1.2 per cent. chloroform vapor in each 30 seconds lowered the blood pressure 90 mm. Hg., which effect is comparable with that of 30 per cent. concentration of ethyl chlorid vapor.

The conditions under which the two series of experiments were performed were not identical so that the comparison is not a strictly correct one. This is owing to the heart lung preparation employed in the chloroform experiments being that of Hering,[14] in which the amount of circulating blood is somewhat less than that of the heart lung preparation employed in the ethyl chlorid experiments. This means that the concentration myocardium than ether.

I have chosen 1.2 per cent. chloroform as the standard for comparison as being a low average anesthetic concentration. Higher or lower concentrations yield different ratios since the intensity of effect increases much more rapidly than in simple numerical ratios with increasing concentrations.

The effects shown above, produced by the action of ethyl chlorid upon the heart are of course greatly exaggerated over those occasioned by similar percentage concentrations upon the heart

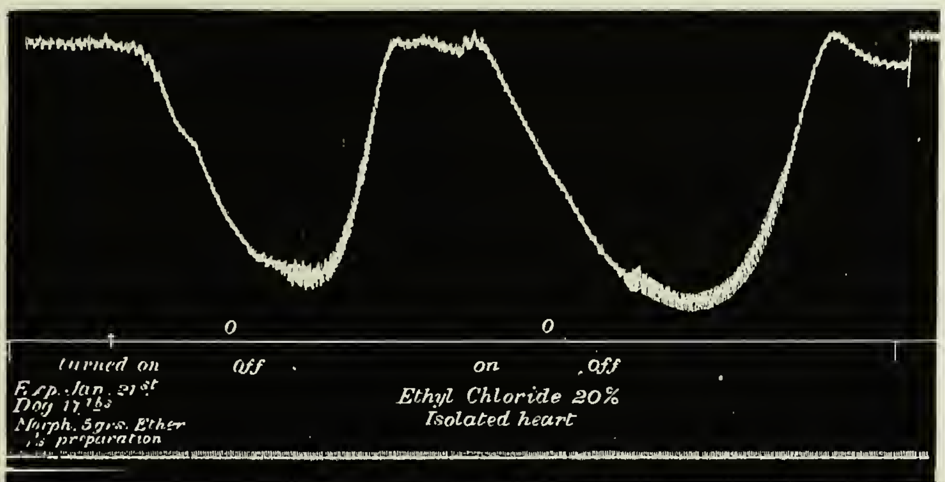


Fig. 6. (3-4 Size of original)—Isolated heart. Recovery. Dog-weight 8.5 kilograms. Morphin 0.32 gram. Experiment similar to that of Fig. 1, but 20 per cent. ethyl chlorid vapor in the air respired. Two experiments were performed. Started at *on* and stopped at *off* after 61″ Blood pressure at start 160 mm. Hg. and fell to 70 in 1′ 30″ It recovered to 160 mm. in 1′ 25″ after stopping the administration. In 33″ after the recovery the administration was again started at tne second *on* and continued for 59″. During that time the blood pressure fell from 160 mm. reaching 62 mm. 1′ 35″ It rose to 162 mm. after administration ceased in 1′ 50″.

of chloroform in the arterial blood rose more rapidly and the effects were proportionately more emphasized. Accordingly I have accepted the ratio 1 chloroform to 19 ethyl chlorid as their relative intensities as heart muscle poisons instead of 1 to 25 as the above figures work out.

By using the figures obtained in a similar investigation into the effect of ether upon the isolated heart[13] by means of the heart lung preparation I estimate chloroform as being 30 times and ethyl chlorid as 1.5 times more depressant to the of the intact animal. This is owing to the volume of blood in the heart lung preparation being a fraction only of the total blood of the animals, and to it accordingly circulating through the lungs with a frequency inversely proportional to their respective volumes. The concentration of ethyl chlorid is rapidly augmented thereby. The intensity of effect upon the heart is correspondingly increased.

It has been demonstrated that four times as great a concentration of ethyl chlorid is required to produce comparable degrees of vagus inhibition of the heart, as that of chloroform, whereas

14. Hering: Phluger's Archives, Bd. Ixxii, Ht. 2 and 3.

it has also been demonstrated that approximately 19 times as much is required to produce comparable degrees of cardiac depression. It is owing to these relative differences that syncope from ethyl chlorid is so much less dangerous than that from chloroform. Syncope may set in from ethyl chlorid before the tension in the arterial blood has reached a height sufficient to seriously depress the myocardium. The excitability of the heart is then still sufficiently unimpaired to enable it relatively quickly to throw off the inhibition. I have never succeeded in fatally arresting the heart by faradic stimulation of the peripheral ends of the divided vagi under any degree of ethyl chlorid narcosis, whereas with chloroform under like conditions, fatal inhibition [12] *is induced.*

Vagus inhibition of the heart with concomitant vasodilation, and myocardial depression are the two great factors concerned in the fall of blood pressure in ethyl chlorid narcosis—the former factor predominating in the instances in which the fall is sudden, the latter in those in which the fall is slowly oncoming.

THE EFFECT OF ETHYL CHLORID ON THE ARTERIES.

(A) The effect on the neuro-musculature of the arteries.

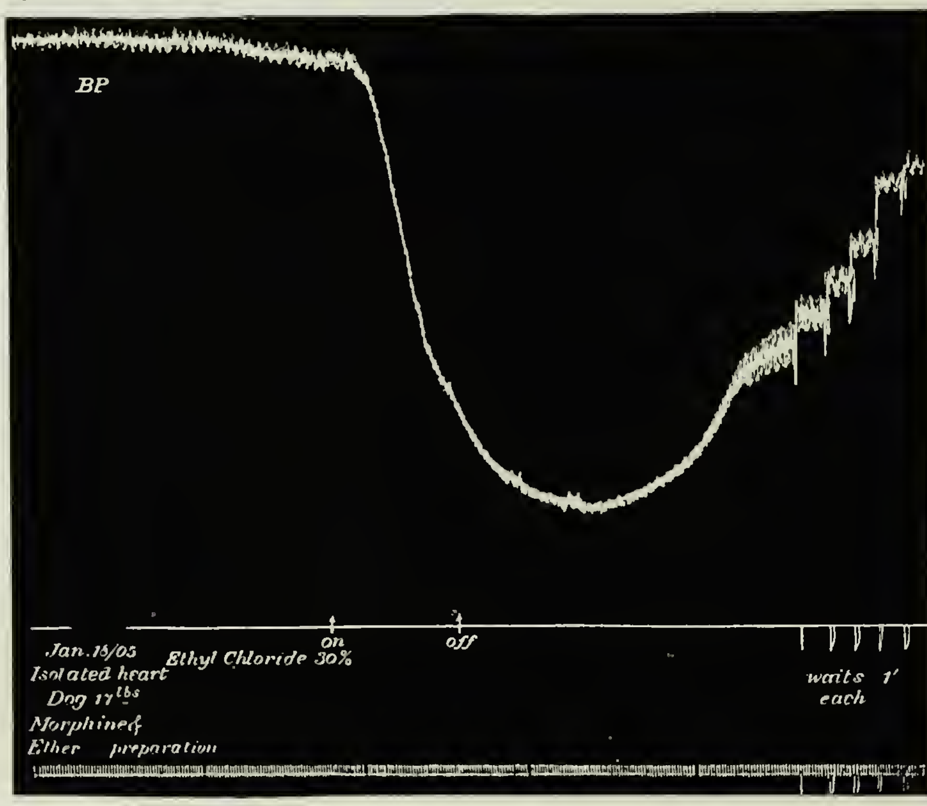


Fig. 7. (12-13 Size of original)—Isolated heart. Recovery. Dog-weight 7.7 kilograms. Morphin 0.32 gram. Preparation as for experiment in Fig. 1. Thirty per cent. ethyl chlorid vapor in the respired air started at *on* and continued 46″. Blood pressure 164 mm. before starting fell to 34 mm. in 1′ 34″. In 2′ 49″ it had risen again to 134 mm. Hg.

Just as ethyl chlorid depresses the neuro-musculature of the heart so it depresses that of the arterioles. The degree of this depression was measured by recording changes in the outflow, under constant pressure, of blood circulating through a loop of excised bowel together with the isolated lungs of the animal[13] to which the ethyl chlorid air mixture was administered by artificial respiration. The apparatus and method employed was that described by Martin and Embley[15] in connection with a similar research with chloroform. The result obtained in form of tracing, showed the drop rate, the time and the pressure, was plotted as a curve in which the ordinates represent the number of drops per minute against time in minutes along the abscissae as shown in Fig. 8. The time during

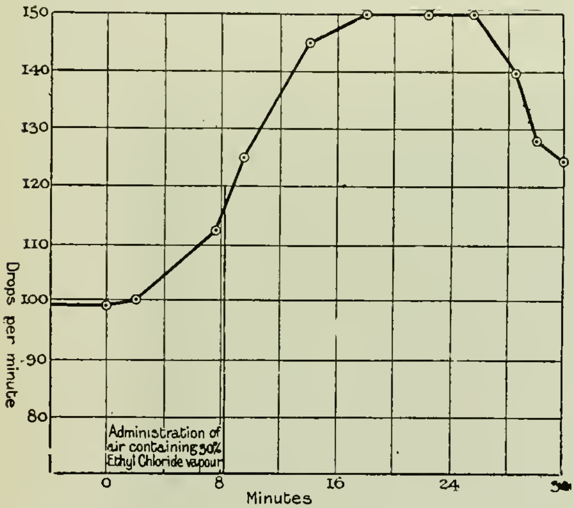


Fig. 8. Double artificial circulation. Graphic representation of the rate of blood flow through a piece of isolated bowel and isolated lungs. Defibrinated blood was circulated. Thirty per cent. ethyl chlorid vapor in the air was administered by artificial respiration to the isolated lung. The curve plotted shows the increase of blood flow through the bowel circuit when the ethyl chlorid was started.

which the ethyl chlorid was given is denoted by the interval between the two lines at 0 and 8. The pressure at which the blood circulated was 80 mm. Hg. throughout.

The degree of relaxation of the vessels is indicated by the increase in volume of blood passing through them, which increase is here shown to be 50 per cent. as caused by the administration of 30 per cent. ethyl chlorid in air to the lungs.

(*B*) *The effects on the central vasomotor nervous system.*

This was investigated by conveying to the brain alone of a curarized dog, by way of the two carotid arteries, through an artificial arterial circulating apparatus, the defibrinated blood of another dog at 38° C., containing various known percentages of ethyl chlorid, for short periods of time. The pressure maintained in the artificial circuit was the same as that of the femoral artery of the dog at the commencement of the experiment.

Fig. 9 is a record of such experiment, showing simultaneous arterial blood pressure and bowel volume curves. The tension of ethyl chlorid in the blood of the carotid circuit corresponded with that of 30 per cent. vapor inhalation. The figure shows that vasoconstriction followed from the first and vasodilation from the two following periods of artificial carotid circulation. Other similar experiments show vasoconstrictor or vasodilator responses vicariously. In one animal for instance, the responses were all vasoconstrictor, in another all vasodilator, while in another they were alternating. Lower percentages evoked similar but less marked responses, being roughly proportional to the concentration.

The excitability of the central vasomotor mechanism is not readily depressed by ethyl chlorid since the vasoconstrictor and vasodilator responses may be elicited for a relatively prolonged period— as long as 45 minutes. The effect of ethyl chlorid therefore upon the central vasomotor mechanism is, for a time at least, stimulative. In this respect also, though less intensely, ethyl chlorid resembles chloroform.

The resultant of the local depressant effect and the central vasomotor stimulation is a fall of blood pressure when the latter is dilator, but an uncertain quantity when constrictor. Efforts to determine this latter quantity by means of simultaneous arterial blood pressure and bowel volume records taken from the intact animal, afford no assistance. The concomitant myocardial depression, slowing of heart rate and changes in the venous volume of the piece of bowel, produce a result too complex for interpretation. However, whether it be a plus or minus quantity is a matter of no clinical noment, since in neither case is it likely to be more than a small fraction of the total blood pressure.

15. Martin and Embley: Journal of Physiology, Vol. 32, No. 2, February 26, 1905.

From the clinical aspect, therefore, the effect of ethyl chlorid upon the vascular system may be ignored except when the response is vasodilator and then only when occurring coincidently with cardiac inhibition as already stated.

The results obtained by vertical rotation of the intact animal into the head-up position during deep narcosis of ethyl chlorid administered by artificial respiration, indicate a degree of vascular relaxation much less than that obtaining in similar experiments with chloroform.

toration of the blood supply. The *second* is *paralytic* and occurs only in instances of more prolonged administration. It arises principally from a higher degree of intoxication of the nervous mechanism of respiration, supplemented by diminished blood supply to the medulla due to the more slowly oncoming circulatory depression.

Table I gives the effects of increasing concentrations of ethyl chlorid upon the respiration. In all of the instances in which respiratory impairment or failure is shown the syncopal form

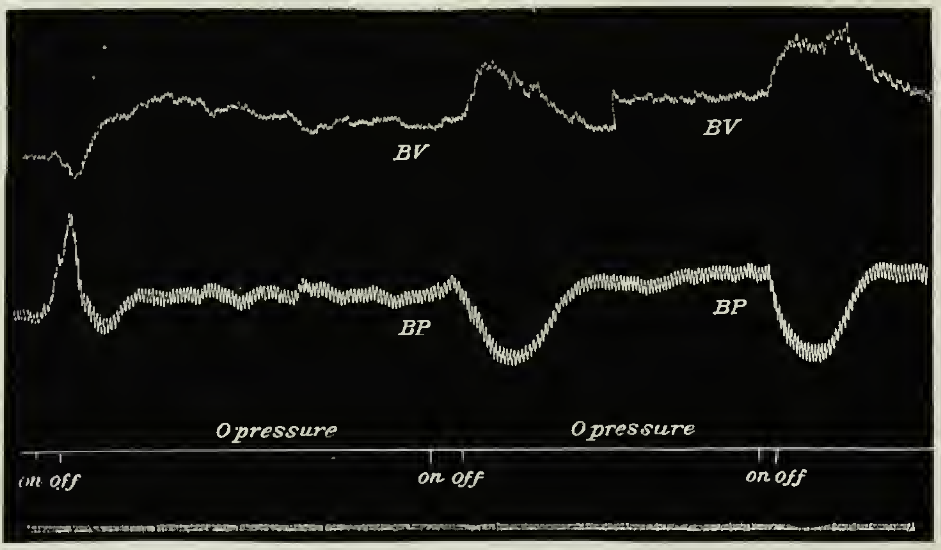


Fig. 9. (1-2 Size of original)—Effects of ethyl chlorid upon the central nervous system. Bowel volume (B. V.) and blood pressure (B. V.) figure. Dog-weight 8.4 kilograms. Morphin 0.3 gram. Curare 0.017 gram. Vagi cut. Artificial respiration. Artificial arterial circulation to the brain of the defibrinated blood of another dog, containing ethyl chlorid equal to 30 per cent. of vapor and at 38° C. The pressure was at that of the dog's femoral artery previous to the experiment. It was delivered by way of the two carotid arteries for period of 19″, 23″, and 13″ in 3 successive experiments. In the first experiment the blood pressure rose 57 mm., while at the same time the plethysmograph lever fell 6.5 mm. in the 19″ occupied by this artificial delivery. In the second experiment the blood pressure fell 88 mm. and the lever rose 15 mm. in the third experiment the blood pressure fell 40 mm. and the lever rose 27 mm. The first result was a constrictor and the second and third were dilator effects.

RESPIRATION.

DURING THESE EXPERIMENTAL investigations two forms of respiratory failure were encountered in the narcosis of ethyl chlorid. The *first*, that commonly met, is the *syncopal*, which arises from the low blood supply to the medulla during syncope, together with a moderate degree of ethyl chlorid intoxication of the nervous mechanism of respiration. The former is the principal factor as is shown by the frequency of automatic recovery following res- occurred—the heart and respiration ceasing or nearly ceasing at about the same time.

Maintenance of respiration is intimately dependent upon that of the circulation in the narcosis of ethyl chlorid. This is especially noticeable in the syncopal form. Given a well sustained blood pressure, failure of respiration can only occur under exceptional conditions. In this respect ethyl chlorid corresponds with chloroform.

In the syncopal form respiration recovers upon restoration of the circulation which ensues upon the heart restarting.

In the paralytic form respiration does not recover automatically. Its nervous mechanism is too much depressed to respond to the rising H ion concentration and the small asphyxial rise of blood pressure—small because venous blood does not bank up on the right side of the heart so that good filling, such as occurs in the syncopal form, is not available for the heart; because the poisoned and asphyxiated ventricle grows less and less effective in driving the blood against the increasing peripheral resistance, and because the tension of ethyl chlorid is practically in equilibrium throughout the blood mass and tissues, consequently that of the heart muscle remains unlowered by the oncoming blood stream. This is the reverse of that which obtains in the syncopal form in which the tension in venous blood is relatively so low that when circulation is restored, the oncoming blood stream promptly lowers that of the myocardium, relieving it of the depression occasioned by the ethyl chlorid and rendering it more effective in its response to the increased demands.

The timely employment of artificial respiration at once tends to counteract the evils of respiratory failure.

The engorgement of the right side of the heart, found experimentally to occur in syncope, has led the pathologist, when performing autopsies upon fatal clinical cases of this kind from chloroform or ethyl chlorid, to pronounce the cause to have been asphyxiation. Such pronouncements in the past, which were generally opposed to the inferences of observers, led to much clinical confusion.

Practically the only form of respiratory failure found to occur in the clinical employment of ethyl chlorid is the syncopal, since this anesthetic agent is rarely used for prolonged anesthetization. The paralytic form, induced experimentally, is similar to that occurring from chloroform under like conditions.

Respiratory failure has not been a factor in the causation of any of the instances of syncope in this investigation, rather, the syncope has caused the respiratory failure. When death has appeared to occur from failure of respiration in clinical instances, the explanation doubtless should have been that respiration failed owing to the circulation having already failed in syncope.

Fatalities may happen from respiratory obstruction by mechanical blockage, laryngeal spasm or any pathological interference with lung ventilation just as in non-anesthetic instances. Consideration of such fatalities does not enter the range of physio-pathology.

CONCLUSIONS.

DEALING WITH THE FACT that ethyl chlorid may cause syncope—sudden cessation of circulation—by exalting the excitability of the vagus and vasomotor nervous mechanisms, when it is administered in excessive concentrations, is the important feature of this paper. Emphasis upon and further demonstration of the circumstance were made necessary by the absence of any instance of such phenomena in the published results of the other workers in this field; also because syncope, not necessarily fatal has been far from uncommon in the clinical usage of the drug. The depressing effect of ethyl chlorid upon the heart muscle causes a more gradual fall of blood pressure; it never occasions sudden cessation of circulation; the oncoming pallor and diminishing pulse volume is slower, and there is plenty of time afforded for warning.

Taking the depressant effect upon the heart as a basis for comparison of relative toxicity, it has been shown that the toxicity of ethyl chlorid is approximately 1/19 that of chloroform. But as the concentration of ethyl chlorid, as employed clinically, is from 10 to 20 or more times that of chloroform, this advantage ceases to have any value. Moreover, in the employment of such high concentrations, cardiac inhibition and syncope are so much more prone to occur than from the concentrations of chloroform used clinically. Accordingly it would seem that ethyl chlorid is a more dangerous anesthetic agent than chloroform. Such, however, is not the case. The time incidence determines the greater safety of the former, since in the syncope of ethyl chlorid, inhibition sets in before the excitability of the heart has become too depressed to break away from the inhibition, so that experimentally the instances of syncope did not prove fatal such as is not infrequently the case in the syncope of chloroform.[12]

This freedom from fatality in the syncope of ethyl chlorid, as shown experimentally, however, applies to the sound heart of the dog. It does not, as clinical statistics indicate, by any means necessarily apply to the human heart, the excitability of which may have otherwise been pathologically depressed.

Failure of respiration in the administration of ethyl chlorid is serious, not because it is a danger in itself, but because most clinical instances are syncopal—the heart having nearly ceased from inhibition when it had set in. It has been shown that the paralytic form of respiratory failure is uncommon owing to this anesthetic agent being rarely used for prolonged operations.

Ethyl chlorid is not as safe as ether, not only because it is approximately 50 per cent. more toxic to the heart, but also because ether, rarely indeed, causes cardiac inhibition and syncope.

If cardiac inhibition be avoided, ethyl chlorid can be regarded as a relatively safe anesthetic agent. Since, however, its rôle in the field of anesthetics is that of rapidly inducing anesthesia, whether for short operations, using ethyl chlorid alone or only for induction in ether sequence, cardiac inhibition is always possible, even probable, in consequence of the high concentrations necessary and the facility with which such are attained, owing to the volatility of the substance.

In my opinion cardiac inhibition can best be avoided by observing the rule of "*promptly removing the mask from the face upon the disappearance of the corneal reflex.*" When so administered ethyl chlorid may be regarded as relatively safe.

BECAUSE WE ARE MEN AND NOT BEASTS OF THE FIELD WE ALL HAVE A DESIRE WITHIN US NOT TO LIVE IN VAIN. THAT IS THE GERM OF VISION AND IT IS FOR US TO SAY WHETHER OR NOT WE SHALL GIVE HEED TO IT AND LIVE BY IT. IF YOU ARE A POET OR A PREACHER, A DUKE OR A DOCTOR, OR AN EVERYDAY MAN YOU HAVE OPPORTUNITY ENOUGH TO GLORIFY THE DAY'S WORK BY ADDING UNTO IT A VISION. THEN YOU WILL TRY TO DO GOOD INSTEAD OF MERELY MAINTAINING A PASTORATE; YOU WILL DELIVER A MESSAGE TO THE WORLD INSTEAD OF MERELY ACQUIRING POETIC LAURELS; YOU WILL SAVE LIVES INSTEAD OF MERELY BUILDING UP A PRACTICE; YON WILL MAKE A HOME HAPPIER INSTEAD OF MERELY PAYING OFF A MORTGAGE. THUS ONLY MAY YOU GROW AND ENRICH YOUR LIFE AND THAT OF MANY ABOUT YOU. WHERE THERE IS NO VISION THE PEOPLE PERISH.

—*Walter A. Dyer.*

COTTON PROCESS ETHER AND ETHER ANALGESIA . FUNDAMENTAL CONSIDERATIONS OF ANESTHESIA . ANESTHETIC POWER AND VARIATIONS FOUND IN MARKETED ANESTHETIC ETHERS . EFFECTS OF ABSOLUTE ETHER . CARBON DIOXID ETHER . ETHYLENE SYNERGISTS . PECULIARITY OF COTTON PROCESSES ETHER FOR ANESTHESIA . METHODS OF ADMINISTRATION . POSTOPERATIVE NAUSEA AND VOMITING . A STUDY OF ANALGESIA . BLOOD PRESSURE VARIATIONS . THEORY OF ANALGESIA . METHODS FOR OBTAINING ANALGESIA WITH ETHYLENE ETHER . WAR ADMINISTRATION . CIGARETTE INHALATION AND WAR ANESTHESIA . NECESSITY FOR EXPERT ADMINISTRATION TO ACHIEVE SAFE AND PROPER RESULTS .

JAMES H. COTTON, M. D. TORONTO GENERAL HOSPITAL TORONTO, CANADA.

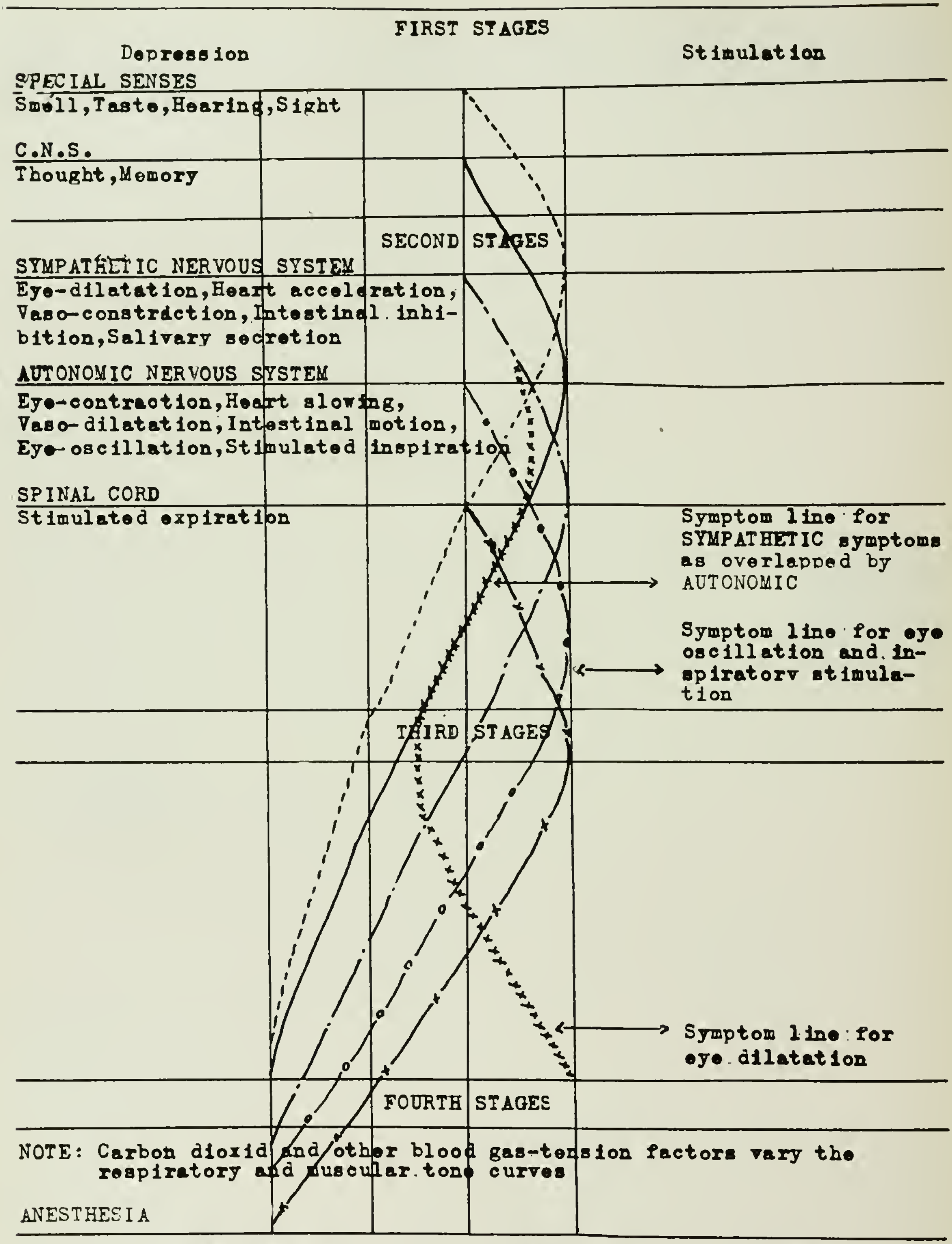
WHEN JAMES H. COTTON first presented his investigations of old and newer ethers before the Canadian Medical Association he challenged many of the time honored signs of anesthesia as evidences of nerve poisoning rather than anesthesia. In an endeavor to purify anesthetic ether he found that absolute ether was not an anesthetic at all. After further researches, in the Laboratories of the Toronto General Hospital and the DuPont Chemical Co., Cotton was able to present and demonstrate his ethylene ether before the Interstate Association of Anesthetists in Joint Session with the Indiana State Medical Association, at Indianapolis, Indiana, September 25-27, 1918, and to elaborate on its pharmaco-physio-pathology as well as the methods for its administration and its availability for maintaining analgesia.

Only a few years ago, said Cotton, it was customary for the anesthetist to classify an ether as good or bad, according to its irritative properties. These were roughly estimated by the annoyance caused the anesthetist by the hypersecretion of mucus and little attention was paid to the amount of ether used or the concentration of its vapor. If a patient did not respond as rapidly as expected to etherization, he was considered an alcoholic or to be otherwise immune to its effects. Some few anesthetists realized that *too closed methods* of administration (Clover inhaler) produced the excessive secretion of mucus, while others improved their results by making the concentration of their ether vapor as uniform and low as was consistent with good, surgical anesthesia.

To establish a clear line of research a series of analyses and administrations were undertaken to determine the actual rôle of the irritative properties of ether impurities. These were divided into (a) *anterior nasal,* due to alcohol or acetones; or (b) *nasopharyngeal,* due to aldehydes. *Smells,* for the most part, were found to be due to the sulphur group.

It was found that the actual irritation value of any ether of standard aldehyde percentage to the mucous membrane, varied inversely with the anesthetic power of the said ether, and directly with the immunity of the patient to ether anesthesia. This presupposed that (1) patients varied; as also (2) the anesthetic powers of different cans of ether.

In proof of the first contention a large amount of ether was mixed and administered to different groups of patients. Five cases of a known al-



SYMPTOMS OF POISONING OF VARIOUS NERVOUS SYSTEMS coholic type were compared with five cases, of a similar weight, but of a type which had not indulged. These patients were from 30 to 35 years of age. The alcoholics required from 25 to 75 per cent. more ether than did the non-alcoholics. Although the variation is not exact, the age and weights propositions were considered as having already been sufficiently proved.

In discussing the variation in anesthetic potency of different cans of ether, an unlimited field of research is entered, that leads back to the startling suggestion of a year ago that: "*absolute ether is not an anesthetic at all.*"

ANESTHESIA.

BEFORE PROCEEDING further it is necessary to come to an agreement concerning the state commonly considered as anesthesia. Personally, *I consider anesthesia as analgesia—blocking of sensory impulses from the periphery, plus narcosis—or sleep.*

When a patient shows a type of breathing, a certain amount of muscular relaxation and contracted central pupil, is he actually surgically anesthetized? For years anesthetists and surgeons have recognized ether anesthesia by a series of such symptoms, and have neglected the fact that patients carried to this stage may still suffer from severe shock, and instead of being anesthetized are in reality only narcotized.

Interpreting each nervous system by the symptoms which customarily arise from it, what results obtain when a pure nerve poison acts upon the nervous system complex? Some well recognized facts are : (1) that a nerve poison acting on any nervous system first stimulates, then depresses, then kills; (2) that the more specialized a nervous system, the more sensitive it will be and the more easily it is stimulated, depressed and killed; and (3) that the order of specialization of the various nervous systems are:

Most specialized:

- Special Senses,
- Central Nervous System,
- Sympathetic Nervous System,
- Autonomic Nervous System.
- Spinal Cord.

Least Specialized:

Now all these stages and symptoms of nerve cell poisoning are those of anesthesia as quoted in the text-books, but not of real anesthesia since they do not in any way fulfill the requirements for the blocking of sensory nerve impulses, and the very basis of the teaching of anesthesia, apparently has been incorrect. Anesthetists and surgeons have been safeguarding the toxicity of ether and neglecting the shock of operation under narcosis, as nerve cell poisoning is simply an additive factor to operative shock.

ANESTHETIC POWER AND VARIATIONS FOUND IN MARKETED ANESTHETIC ETHERS.

THREE YEARS AGO statistics affecting 150 abdominal cases operated under anesthesia by a certain brand of ether were compared with the results in another 150 similar cases, anesthetized with another make of ether. With one ether, after induction, from 4 to 8 ounces were required per hour of maintenance; with the other ether from 6 to 12 ounces. From the aldehyde research it had appeared likely, but this was the first actual record that anesthetic ethers could vary in potency. It was found that the more potent ether contained traces of gases as well as more alcohol. Clinical trial of the weaker ether, in some ten cases, by increasing the alcoholic content, while it lowered the freezing point of exhaled moisture preventing mask frosting and retaining ether and ether products on the mask longer, did not vary its anesthetic potency. It was, therefore, reasonable to suppose that some factor, other than alcohol, varied the anesthetic potency of an ether.

Research was then undertaken to obtain absolute ether from the commercial ethers already on the market. At that time these ethers were in a far more impure state than they are now, as the fusel oil groups were always detectable. After one and one-half years of hard study and work, a sufficiently chemically pure ether was obtained to warrant its clinical trial on patients.

This ether was so mild in odor that it could have formed the basis for any perfume. To the surprise and chagrin of all concerned, on administration, it was found not to be a good anesthetic. Dr. Samuel Johnston, a noted Toronto anesthetist, used 15 ounces on a middle-aged patient, who was congested to blueness without mucus secretion and without the production of proper anesthesia. There was a severe struggling stage, while muscular rigidity and sensory reflexes persisted and could not be suppressed. A few drops of Squibb's ether were then administered and the patient sank into a quiet anesthesia without sensory reflex. Very little more Squibb's ether was required during the whole of that operation. Excessive after-sickness resulted. Dr. Perfect, who was the surgeon, also vouches for these facts. This same ether, *when perfectly fresh*, was used on nine other cases,—all dental. Although symptoms of nerve poisoning resulted, no real anesthesia was produced in any one case, although from 9 to 14 ounces had to be given before the patients were stupid enough for extractions. Instead of sensation being obtunded it frequently became hyperesthetic. Persistent muscular tremor and peripheral congestion occurred in each instance. On going under patients complained of *feeling perfectly awful* and post-anesthetic nausea and vomiting usually resulted. The pulse rate rose very high during induction.

This same ether was then given to three cats for experimental purposes. Each cat was carried to the point of suspended respiration and then resuscitated. At no time were the muscles relaxed and although the cats were completely narcotized, the leg would twitch on being pricked with a pin. The recovery on resuscitation was almost immediate. After being supposedly killed three times, an apparent anesthetic condition could be obtained, but this was probably due to exhaustion. A few months ago this experiment was repeated in detail before a number of interested witnesses at one of the experimental stations of the DuPont Chemical Works, but since then similar results have not been found by these chemists.

From the above data it was concluded that absolute ether was not a good anesthetic and that real anesthesia could not be obtained unless it contained some potent synergist as yet unknown.

The first cooperative thought of was carbon dioxid. It was found that the peripheral spasm and muscular tremor following the administration of from 6 to 8 ounces of absolute ether, could be completely relieved by a small amount of carbon dioxid. As described in a previous paper, this *carbon dioxid-absolute ether anesthesia* is a type of its own. In a demonstration given at the Academy of Medicine, Toronto, I compared the action of absolute ether with that of nitrous oxid, in which the carbon dioxid tension factor is also a necessity. The anesthesia produced by this carbon dioxid-ether method is very similar to that obtained from nitrous oxid and the recovery is almost as rapid. In practice, it was found convenient to administer the carbon dioxid in a solution with ether in a metal syphon-soda arrangement with a controller similar to that used on the glass ethyl chlorid tubes.

Over 20 operations of a major as well as many cases of a minor type were performed under carbon dioxid-ether anesthesia with excellent results. There was no real after-nausea in any one case. The amount of ether averaged about 5 ounces an hour. The only objection to the anesthesia was the excessive stimulation of respiratory effort. The color and pulse were good and no case showed mucus. The patient on whom the method was demonstrated at the Academy of Medicine, Toronto, joined the physicians in attendance, and had coffee with them within three minutes after his extraction operation.

While clinical experiments continued in the operating room, ether research progressed in the laboratories, as there was not considered to be enough carbon dioxid in most commercial ethers to act as the potential factor in anesthesia. *It was then discovered that this absolute ether on being passed through a certain process, developed wonderful anesthetic powers.* Its analgesic properties were such that almost major operations could be performed with the patient still able to articulate clearly, without pain and not at all sleepy. More concentrated administration produced beautiful, quiet, sleep anesthesia, without shock. After a certain length of time, however, this product would deteriorate to an unusable degree, although the analgesic power increased in more than equal proportions. A few breaths, although fairly irritating, would produce almost completely obtunded sensation for some hours. Six cases were tried, including myself and friends, and we began to wonder if we were ever going to completely recover our feelings. We were otherwise normal, except for a slight sluggishness of memory.

Careful concentration and extraction of gases from this product demonstrated the presence of certain ethylenes and their by-products. As these were not present in the absolute ether base, they must have developed in the process.

Ethylene gas was then made by text book methods and added to absolute ether. It transformed absolute ether into a moderately good anesthetic, but the results were not comparable with those previously obtained; in fact such ether was by no means as good as Squibb's. However, with careful synthesizing and research, anesthetic synergists of exceedingly high value and potency were finally obtained.

The product, now recognized by the medical profession as Cotton Process ether, is simply ether, purified to an almost absolute stage by the methods originated, plus these synergists. As these synergists were for the most part of a gaseous nature it was considered desirable to retain them in the ether in greater quantities than would remain at ordinary atmospheric pressure. With this end in view the ether has been kept in sealed glass ampules of about 1 ounce capacity, the idea being to administer it direct from such containers.

PECULIARITIES OF COTTON PROCESS ETHER FOR ANESTHESIA.

ALTHOUGH THIS ETHER was primarily developed for analgesia only, a number of anesthetists and surgeons have used it and have reported it satisfactory for anesthesia.

Method 1—Administration from Drop Bottle on Open Mask. This method, though apparently successful, should never be used, as ether gases of great anesthetic value are allowed to escape. By this method the anesthetic power is about that customarily obtained from any good commercial ether, the after-effects being possibly less.

Case 1. Patient, female; age 28, weight 160 lbs.; operation for intestinal adhesions; induction gas-ether; time 4 to 6 minutes; time of operation 1 hour. Amount of ether used 8 ounces by volume on open mask. Condition during operation: absolute relaxation; no mucus; color and pulse normal.

Method 2—Administration Direct from Ampule on Open Mask. The glass tip of the ampule is broken off and the end of the ampule is inserted into the rubber socket of a device similar

DEVICE FOR ATTACHING TO ETHER AMPULE.

to the automatic cut-offs of ethyl tubes. The gas pressure in the ampule is sufficient to expel the ether when the cut-off is opened and the ether is dropped or sprayed on the mask as with ethyl chlorid.

Case 1. Patient, female; age 41; weight 104 lbs.; pulse 120; operation, thyroidectomy. Previous medication 1/6 gr. morphin and 1/200 gr. atropin 20 minutes before anesthesia. Administration: pulse immediately after induction was 110. During the operation it dropped to 100, then to 80. On recovery it registered 108. Time of induction 3 minutes; time of operation 1 hour. Patient recovered sufficiently to speak in 20 minutes. Was somewhat drowsy for several hours. Amount of ether used 5 ounces. No after-nausea. Surgeons: Drs. Perfect and Harrison.

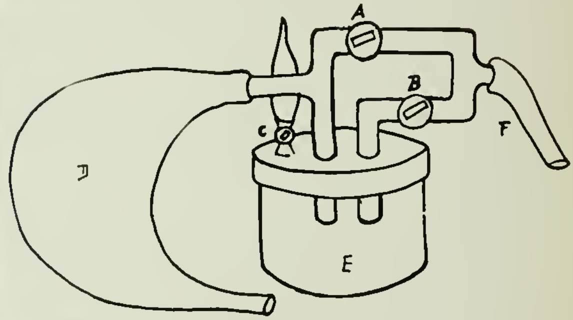
Case 2. Patient, Mrs. C.; age 70; weight 112 lbs.; operation, breast amputation. Administration: time of induction 6 minutes; operation 1 hour. Amount of ether used 5.5 ounces. No after-nausea and patient recovered before reaching room. Stated she had enjoyed going under. Surgeons: Drs. Hay and Wesley.

Method 3—Oxygen Semi-Closed. A. Gwathmey Apparatus. The value of this method was first drawn to the author's attention by Dr. J. F. Baldwin of Grant Hospital, Columbus, O., who was the first surgeon to use highly charged ether in any moderate series of major cases. The technic is one of Dr. R. A. Rice's "Perfected Methods of Anesthesia" (described in the American Year-Book of Anesthesia & Analgesia, 1915-1916) in which oxygen, from a low pressure tank, is led through the Gwathmey three-bottle, dosimetric vapor apparatus, with its ascending and descending percentage control, and the saturated oxygen-ether vapor, washed and moistened in the warm water bottle, is conducted by means of a rubber tube to a closely fitting face mask, or oral air-way, to which is attached a rebreathing bag. Baldwin reported 20 abdominal operations car-

RICE PERFECTED METHOD FOR VAPOR ETHERIZATION.

ried out, from start to finish, with this apparatus and method of anesthesia. The amount of ether used averaged from 1 to 3 ounces. The recovery was more rapid and the after-effects less than those occurring with ordinary ether. With this ether and method it was possible to induce anesthesia by the vapor method, whereas, previously, with other tinned ether, ethyl chlorid was always used for induction and almost double the amount of ether was found necessary for maintenance.

B—Modified Vapor Apparatus. This apparatus was designed to provide a vapor device with a large ether container, providing area sufficient for surface evaporation, thus obviating the undesirable feature of carrying over ether particles, as they are bound to be when the oxygen is passed through the ether. The ether is placed in the container (E) through a tap in the top of the container, all ether gasses being thereby retained. Oxygen is admitted from a low pressure tank into (D) a soft rubber bag at the rate of about 10 litres an hour. With the mask fitted tightly over the patient's face, tap (A) is opened, permitting the breathing of oxygen, then tap (B) is slowly opened, allowing part of the oxygen to carry over



MODIFIED VAPOR APPARATUS FOR ETHYLENE ETHER.

ether vapor. As more ether is required tap (A) is closed down. Excess rebreathing, causing dysphonia, may be rectified by emptying bag (D). The whole apparatus is hung on the oxygen tank.

This method is positively fool-proof for Cotton Process ether and will maintain the patients uniformly at any required depth of anesthesia. With it the new ether shows over double the anesthetic potency of tinned ether and recovery is almost instantaneous.

C—Perfected Apparatus. This is described under the consideration of analgesia and was developed to provide a simple, portable device, especially available for war purposes.

Case 1.—Patient, nurse; age 28; weight 125 lbs.; operation, removal of tonsils. Administration: author's special apparatus. Time for induction 4 minutes; complete surgical anesthesia apparently obtained. Time for removing first tonsil 2 minutes; patient then completely awake but without feeling. She carried on conversation for 3 minutes when mask was reapplied; anesthesia reinduced in 1 minute. The same rapid recovery after removal of second tonsil. Soreness in throat was not detectable for over one-half hour and during this period patient took nourishment. She considered the whole procedure a very pleasant experience. Amount of ether used 1.5 ounces. Throat reflex present before each tonsil was completely removed. Surgeon: Dr. Perfect. Witnesses: Drs. H. Harrison and Carveth.

Case 2. Patient, Mrs. B.; age 35; weight 115 lbs.; operation, removal of 14 teeth. Administration: author's apparatus, patient in sitting posture. Time of induction 4 minutes. Patient held her own mouth open. Did not complain of pain for 10 minutes. Anesthesia was reinduced in 2 minutes and the remaining teeth removed. Patient was quite awake all the time and was able to walk about afterwards. Amount of ether used 1.5 ounces. Surgeon: Dentist. Witnesses: Drs. Carveth, Perfect and Harrison.

Report from Mrs. B.: Arrived home about 1.30 P. M. feeling pretty good considering, so much so that I walked home rather than get in and out of street car. Had a cup of tea and soaked biscuit and laid down. When taking the ether I did not have any going away sort of feelings and was not at all nauseated. I can remember coming round partly before the dentist finished, but it caused me no pain. I could have eaten hot roast pork had there been any and my mouth permitted.

(Signed) Lillie Booth.

Case 3. Patient, female; age 35; weight 115 lbs.; operation, cholecystectomy and appendectomy. Administration: author's apparatus. Time of induction 5 minutes. Previous pulse 100; pulse during operation 70. Relaxation during first part of operation easily obtained. Duration of operation 1 hour and 20 minutes. Amount of ether used 3.5 ounces. Regurgitated 4 ounces, but did not remember it or suffer from after-nausea. Patient was able to walk while being returned from the operating room. Surgeons: Drs. Perfect and Harrison.

Personally I have found that by open methods, although the amount of ether required is not large, patients recover so rapidly from deep stages of anesthesia that a careful and even drop-rate administration is required. By the oxygen semi-closed vapor apparatus the maintenance of anesthesia is much more regular. If anesthesia is badly administered, however, a certain amount of salivation may result. The Carveths of Toronto consider the new ether ideal as an induction anesthetic, for it is very rapid, and out of a fair number of cases they have not yet noted any excitement stage. They maintain anesthesia by any method whatever, except in abdominal work. Here, they state that the patient's muscles cannot always be completely relaxed, although there is never any muscular spasm. This opinion has been corroborated by some other anesthetists and therefore deserves consideration.

POSTOPERATIVE NAUSEA AND VOMITING.

FOR YEARS, postoperative nausea and vomiting have been recognized as the great disadvantages of etherization. In a previous paper it was shown that carbon monoxid may be produced by the superheating of ether in contact with metal and the slightest trace of this poison, when present in ether, will cause severe nausea. It is frequently introduced into ether by the high temperature from soldering the can. *It must also be remembered that if an ether is not a sufficiently potent anesthetic, due to the absence of its synergists, a very large amount of the ether or narcotic group will have to be administered, and postnarcotic nausea and vomiting must follow.*

With ethylene ether nausea and vomiting after patients have awakened has not yet occurred, as far as the author has been able to secure information, but regurgitation before awakening has taken place in the use of oxygen semi-closed methods of etherization when the administration was stopped too abruptly.

In selecting patients for this anesthetic attention should always be paid to the urinary analysis in order to detect the presence of any degree of acidosis. In judging the sickening effects of any anesthetic it is well to bear in mind the following two facts: (1) Postoperative nausea rarely occurs in elderly people, especially when they are suffering from any degree of heightened blood pressure; and (2) a certain class of operations having to do with the intestines and especially the gall-bladder, will, of themselves, give rise to nausea and vomiting.

ANALGESIA.

THIS WHOLE RESEARCH was undertaken to develop some reliable method of producing analgesia, especially for the handling of war wounds, and during its course the following data were secured for study:

Exhibit A—Comparison of Induction Analgesia with Absolute and Ethylene Ethers: Oxygen Semi-Closed Method. Absolute ether was first administered to 12 cases and the results studied relative to blood pressure, pulse rate, analgesia and after-effects. Two days later a similar series of administrations were undertaken on the same cases with absolute ether containing a large amount of ethylene derivatives.

With the absolute ether the blood pressure immediately rose 16 to 20 mm., systolic, whereas when ethylene was present in half the instances it dropped 10 mm., in three it remained normal and in the remainder it rose 10 mm. With absolute ether analgesia resulted in six cases, while the other six patients became hypersensitive and remained so until they fell asleep. *The period of analgesia occurred in all cases in which ethylene ether was administered, long before the patients became unconscious.*

Patients inhaling absolute ether complained of a very depressing sensation during the induction and most of them went into a struggling stage, at which point the administration of the anesthetic was stopped. Their recovery was exceedingly slow and violent headaches invariably occurred within an hour. Those patients taking the ethylene ether enjoyed going under; there was no excitement or struggling stage; recovery was almost instantaneous and none complained of unpleasant after-effects.

Exhibit B—Rebreathing of Oxygen. As methods involving the rebreathing of oxygen had been found useful for the administration of ethylene ether, it was thought desirable to study them more closely. Vapor-apparatus similar to that described under Anesthesia was used. The ether container was filled with caustic potash sticks in order to absorb any accumulation of carbon dioxid. An excess of oxygen was given,—10 to 20 litres per hour, and the blood pressure readings were closely followed in 20 cases. Eighteen of these showed a slight drop in systolic and a fair rise in diastolic pressure. The other two had their rise in diastolic, but their systolic pressure did not vary. The pulse rate remained normal in all cases.

Exhibit C—Blood Pressure Variations. The figures in Chart I are the average of those recorded with a commercial ether containing very little ethylene and those in Chart II with an ethylene saturated ether, respectively.

BLOOD PRESSURE VARIATIONS: CHART I.

Time	Systolic	Pressures Diastolic	Pulse	Pulse Rate	
Previous	120	80	40	80	
1	150	70	80	116	
2	160	72	88	96	
3	160	90	70	80	Beginning Analgesia: not Surgical
4	130	100	30	80	
5	135	110	25	80	
5.5	145	118	32	80	
6	150	118	27	80	
6.5	140	90	50	80	
7	130	85	45	90	No Analgesia
7.5	128	90	38	100	
8	120	85	35	110	
8.5	118	100	18	100	
9	115	105	10	90	Struggling Stage
9.5	110	85	35	90	

BLOOD PRESSURE VARIATIONS: CHART II.
An ethylene saturated ether.

Time	Systolic	Pressures Diastolic	Pulse	Pulse Rate	
Previous	120	75	40	80	
1	130	90	40	90	
1.5	140	100	40	100	
2	140	105	35	80	Analgesia to Surgical Degree
3	140	100	40	80	
4	120	90	30	72	Sleep
80 mins.	120	90	30	72	Anesthetic stopped
85 mins.	130	90	40	85	

From these figures it is readily seen that the ethylene group acts as a stabilizer of the circulation. Relative to the struggling stage it was observed that this complication always seems to occur when the pulse pressure was extremely reduced by a decrease of systolic as well as a rise in diastolic blood pressure. Patients, sufficiently conscious at this stage, blamed their restlessness on a peculiar numbness,—not analgesia, as well as a hollow sensation in the abdomen. With the onset of sleep there always occurred a drop of about equal degree in both the systolic and diastolic pressure. Whether this drop is responsible for sleep is a question that can only be satisfied by circumstantial evidence.

THEORY OF ANALGESIA.

BEARING IN MIND the data developed in *Exhibits A, B and C*, it is of interest to study the various physico-chemical changes of *state of solution* and *vapor tension* of ether as it passes through the blood stream, with the view of determining how ethylene synergists may act in producing analgesia.

The boiling point of absolute ether is about

34.5° C. When ether is administered it passes through the walls of the alveoli to enter into solution in the blood circulating in the lung tissues. The temperature of this blood is between 36° and 37° C., or 1.5° to 2.5° C. above the boiling point of ether. On this account an ether-gas-tension will develop, thereby limiting the amount of ether that can enter the blood stream.

The point of maximum heat production in the circulation is in the end capillaries of the peripheral tissues where combustion takes place. Here the temperature suddenly rises to over 39° C. It will be easily understood, therefore, that when the ether from the lung tissue reaches this point through the arteries, the gas tension will be enormously increased, both on account of the lowering of pressure and the increasing of temperature.

Ether, like alcohol, acts centrally and otherwise on the nervous system to cause a general vasodilatation, thereby slowing the blood stream in the capillaries and reducing the metabolism and temperature. This is shown by the drop in diastolic pressure taking place on the administration of absolute ether.

Volatile anesthetic substances enter the blood stream at the lung capillaries much more slowly than does ether. If they are present in the ether administered, the vasodilatation caused by the ether will be replaced by vasoconstriction as soon as they gather in the peripheral circulation in sufficient concentration. That is, the administration of an ether together with these anesthetic gases, is followed by a short period of vasodilatation, succeeded by vasoconstriction and increased capillary combustion. During this vasodilatation the heart will beat more rapidly due to the relief of pressure, but as soon as vasoconstriction develops, the pulse slows down with the increasing resistance.

It has already been emphasized that when ether only is present in the blood stream there is an ether-gas-tension increasing in the peripheral tissues, which is lessened according to the resulting vasodilatation, by the reduction in metabolism as well as the relative approximation of blood pressure between arteries and capillaries. Thus it can be seen that when the ether-gas-tension in the capillaries becomes very great and these capillaries are constricted, there will be an enormous escape into and retention of ether in the surrounding tissue fluids, and the ether becomes concentrated in the lymph and tissue cells. When this concentration is sufficient the sensory nerve endings lying in the tissue fluid will become insulated and no longer able to function. The motor nerve endings are not affected as they enter directly into the cells that they govern.

In the central nervous system, where the metabolism is not nearly so great, the ether will not localize. In other words, if the capillaries throughout the body are kept normally constricted, ether will localize in tissues according to their state of metabolic activity and this localization produces localized analgesia by sensory nerve ending insulation. The blood pressure curves, already charted, show that ethylene and carbon dioxid (as we have already assumed), tend to equalize the circulation by lowering the systolic as well as raising the diastolic pressure. Oxygen, as has been shown, does practically the same thing, to a much lesser extent, and therefore might also be classified as a synergistic gas.

It must be remembered in this connection that volatile anesthetic substances cannot maintain constriction of capillaries unless the nerve control of these capillaries is healthy; and without this maintenance marked analgesia is impossible. Bearing on this point is the fact that it is exceedingly difficult to obtain analgesia (without narcosis) in patients suffering from anemia, hemorrhage, syphilis and prolonged fever.

METHODS FOR OBTAINING ANALGESIA WITH ETHYLENE ETHER.

THESE METHODS aim to utilize all the gases in ether, as the analgesic power of an ether depends on their presence.

Method A—Open Mask Administration Direct from Ampule. An arrangement such as described under *Method 2* in Anesthesia was found convenient.

ILLUSTRATIVE CASES.

Case 1. Female; weight 180 lbs.; age 42; operation, breast amputation; time of operation, 45 minutes; anesthetist, Dr. Carveth. Patient capable of talking throughout whole of operation. She had no pain whatever and could not feel on what part of the body they were working. Ether used, 5 ounces.

Case 2. Male; Base Hospital, Toronto; weight 150 lbs.; age 48; operation, resection and cauterization of part of abdomen for cancer; time of operation, 1 hour. Patient capable of talking throughout and quite clear mentally. He complained of being hungry before the hour was up. Pain returned within 3 minutes of cessation of anesthetic. Ether used, 3 ounces.

Case 3. Male; age 18; weight 180 lbs.; operation, adhesions and resection of tubercular mass from abdomen. Time of operation, 1 hour and 10 minutes. Patient remained very clear mentally and cracked jokes throughout. He was given a small meal while the surgeons were operating on him. Abdomen was completely relaxed, except at one time when he insisted upon kissing the nurse. Eyes were slightly dilated and pulse remained at 80. Amount of ether used, 3 ounces.

Case 4. Male; aged 48; weight 132 lbs.; operation, opening and scraping abscess. Time for induction, 5 minutes. Senses dulled and unable to talk clearly. Length of operation, 12 minutes. Amount of ether administered, 2 ounces. Patient held his breath for one-half minute during recovery, which was complete in one minute. Patient then changed tables himself. There were no after-effects. Surgeon: Dr. Harrison. Witness: Dr. Carveth.

Case 5. Male; aged 33; weight 190 lbs.; returned soldier; operation, opening arm. Patient complained of feeling dull, but otherwise felt normal. Time of operation, 45 minutes. Time of induction to analgesia, 6 minutes. While under he stated he did not simply want to lose sensation to pain but that he wished to go to sleep, as he was tired. Amount of ether used, 3½ ounces. At two previous operations it was impossible to induce him with commercial ethers and chloroform had to be resorted to.

Case 6. Male; aged 42; weight 140 lbs.; operation, resection of teeth from ankylosed jaw. Time of induction, 4 minutes. Time of operation, 1 hour and 40 minutes. Amount of ether used, 6 ounces. Patient sat up and held his head in position while teeth were resected from jaw. He had no sensation whatever to pain. He answered the phone twice during the operation and seemed to be in possession of all his mentality.

Case 7. Comparison of Cotton Process Ether with ordinary C-E Mixture. Patient, aged 24, on account of a recent attack of pneumonia was to be operated on under local anesthesia for an acute appendiceal condition. She was given ¼ gr. morphin and 1/200 gr. atropin as a preliminary, as she was exceedingly nervous. At 11 P. M. she entered the operating room and the skin over the site of the operation was carefully infiltrated with 0.1 per cent. anocain solution. Six minutes later the incision was made, but the patient was unable to stand further manipulation on account of the deep soreness of the underlying abscess. At the request of the surgeon the houseman started the administration of the C-E Mixture. The patient became excited, and after 1½ ounces had been used she dropped into a light sleep, but the abdominal muscles were extremely rigid and there was a tendency to stop breathing. The incision made through the anterior aponeurosis was followed by severe muscular spasm. I then suggested the use of an ampule of ethylene ether on the open mask. The patient was allowed to wake up and the ethylene ether was then given on the open mask, without the usual surrounding towel. Within four respirations her muscles relaxed completely and she was entirely without sensation, although she was able to answer questions clearly and was not excited, and would do anything requested. The operation continued and the abdomen was opened. The appendix had not ruptured, but the whole of the cecum was adherent to the abdominal wall and pelvis. One ounce of ethylene-ether had been used by this time and as another ampule had to be fetched from the storeroom, the C-E Mixture was again administered to note its effect. Sensation returned and the patient became blue if the C-E Mixture was pushed. Ethylene ether was again used. The patient woke up and was able to talk. Her abdomen again relaxed. Operation continued for one hour. Adhesions were broken down and the appendix successfully removed. Three ounces of ethylene ether were used. During its use, at any time during the operation, the patient could have walked as easily as she talked. Afterwards she remembered answering questions but did not know anything about the operation while under the ethylene ether.

One peculiar fact was noted. While under ethylene ether the pulse ranged about 80 and under the C-E Mixture it would immediately rise to 120. The patient stated that she was hungry and thirsty during the operation, as she was also afterwards. There was slight dilatation of the pupils, but otherwise they were normal. They would roam about when covered, but fixed on any object when allowed to see.

Patient was as clear mentally at the end of the operation as at the beginning. Pain recurred within 3 minutes after cessation of the anesthetic.

Other Cases.

- 15 Obstetricals: These patients were entirely relieved from pain, without reduction of the expulsive effort. Six were primiparæ and in four forceps had to be resorted to. One case was an induced delivery of a dead fetus at 8 months, while in another instance operative measures were required on account of hydrocephalus.
- 59 Cases of successful Analgesia reported by Dr. Hudson.
- 9 Dental cases reported by Dr. Carveth.
- 32 Dental cases reported by the Dental Department of the Toronto General Hospital.
- 6 Dental cases for relief of pain for drilling.
- 6 Breast Abscesses.
- 40 Administrations for Dressings.
- 1 Epispadias Operation.
- 2 Hernias.
- 4 Varicoceles.
- 4 Abdominal Operations.

B—Bottle Inhaler Method. Two varieties of this apparatus have been perfected. In each a bottle capable of holding at least 4 ounces was used. The cork in the simpler form was perforated by two tubes, one of which opened to the air and the other T'd off to nasal tubes coming from the nose of the patient. Ether was introduced through open tube to the bottle and patient breathed in through the nose and out through the mouth, as required. Valves were later introduced to prevent the patient from breathing back into the ether bottle. In the more complicated variety the same principles were accomplished by a single perforation of the bottle cork by means of sleeve tubes connected with the valve. This method of administration was found quite unsatisfactory in a number of cases, as it was difficult to teach patients how to breathe, and they would constantly forget as their memory became undermined by the ether. It was used successfully in over 100 administrations for painful dressings and in 20 obstetrical cases. In deliveries, however, a number of failures to secure satisfactory analgesia, by this method of administration, have been reported.

WAR ADMINISTRATION.

OPEN MASK ADMINISTRATION in war surgery would be out of the question, as the patients are difficult to induce and it is important to conserve every particle of ether on the battlefield. With this end in view the inhaler bottles were at first thought suitable. Dr. Foot, now in service, attended to the origination of the details of these bottles. They proved unsuitable, as too much time had to be consumed in each case teaching the patients how to breathe properly.

The mask, herewith illustrated, was then conceived and made by the author, and it accomplishes the purpose. With its use analgesia results after four breaths of the anesthetic have been taken and one only depends on the patient to hold the mask in place.

One case lately demonstrated at the Western Hospital was a woman who had been knocked down by a motor car and had her clavicle fractured. She was prejudiced against taking any anesthetic until told that she could give it to herself. The patient talked throughout the whole operation and was entirely without pain until six minutes after the anesthetic was stopped. She then stated that she wanted more of it as it made her happy. There were, of course, no after-effects. Major Harrison of the British Army was in charge of this case. A second case was undertaken with this same apparatus. The patient was 70 years of age and weighed 110 lbs. The operation was to open a knee joint. It required 2½ minutes to induce analgesia. The time of operation was 12 minutes. About one ounce of ether was used and the patient was not at any time abnormal mentally.

The photos are, for the most part, self-explanatory. Figs. A and B, view the mask from the side, while C shows the face part. Fig. D represents the shutter by which the ether is turned off and on. With the handle of the shutter turned toward the nose the patient breathes directly into the bag. The shutter is rotated toward the Intake Tap to turn on the ether. The anesthetic can be poured into the vaporizing chamber by unscrewing the tap or an aliquot can be introduced direct from the ampule by inserting it into the Intake Tap.

For prolonged analgesia or anesthesia oxygen is run into the bag at the rate of from 6 to 12 liters per hour. If the accumulation of carbon dioxid becomes excessive in the bag, and the patient's breathing becomes stertorous, the bag is emptied of its gases, and the patient is allowed a few breaths of air. For brief analgesia or anesthesia oxygen is not required and the patient is ordered to fill the bag with one or more big exhalations before the anesthesia is started.

For ordinary dressing cases or the probing of wounds, only 1 or 2 cc. of ethylene ether are required when this mask is used. As many as 12 dressing analgesias have been induced with one ounce of this ether.

CIGARETTE INHALATION AND WAR ANESTHESIA.

ONE VERY IMPORTANT point with regard to war surgery is that of cigarette inhalation immediately previous to anesthesia by any ether. If the soldier patient has inhaled cigarette smoke within ten minutes of his induction, the systolic blood pressure will rise from 30 to 100 mm. beyond that rise which would normally take place, and even dilatation of the heart may result. He will also invariably suffer from a headache afterwards. Cigarette inhalation following an anesthetic always aids the recovery of patients from the effects of the ether.

NECESSITY FOR EXPERT ADMINISTRATION.

MANY HAVE COMPLAINED to the author that in order to use this gas-ether they had to learn new and complicated methods of administration, and they did not seem to recognize that this knowledge simply allows them to understand the materials they thought they were so familiar with. In fact, the complaint only goes to emphasize that anesthesia is a speciality requiring the highest possible education in both chemistry and physiology. Unfortunately, certain members of our profession, due most likely to their lack of interest in the subject, have adopted the layman's view that an anesthetist is a mechanical technician, who pours a certain dose of an anesthetic down the neck of his patient. The places of these few might, with profit, be taken by a nurse or trained orderly, as such could certainly not be called anesthetists. They are, at best, assistants to the surgeon. If this view is persisted in it will not only endanger human life, but further progress in anesthesia will be completely blocked and a blissful ignorance will reign.

A number of nurses, who have witnessed analgesia work with gas-ether for dressing cases, have been delighted, inasmuch as they considered the thing so simple that it represented the beginning of the reign of nursing anesthesia. For light analgesia, such as is required in the dressing of fresh wounds on the battlefield, anesthetist technicians may be able to use this ether and method of administration, when emergency demands, but for major surgery a great deal more knowledge of the intricacies of anesthesia is required for its use than has heretofore been necessary.

This whole research was persisted in for the sole purpose of securing an ether for painful dressings, and if it can be utilized efficiently to make things more bearable for the boys at the Front, our purpose will have been completely accomplished. The theoretical and operative work mentioned in this paper were simply undertaken to this end and the results are given to the profession for what they are worth.

WHAT IS THE LURE OF ANESTHESIA? TO MY MIND IT LIES CHIEFLY IN THE VARIETY OF THE WORK. THE PROBLEMS ARE ALMOST ENDLESS; THEY ARISE FROM THE STATE OF THE PATIENT, THE NATURE OF THE OPERATION AND THE SPECIAL DEMAND OF INDIVIDUAL SURGEONS, ALL OF WHICH MAY BE, TO A CERTAIN EXTENT, ASCERTAINED BEFOREHAND. ON THE TOP OF THEM ALL, HOWEVER, IS THE PATIENT'S IDIOSYNCRASY—AN UNKNOWN QUANTITY. THERE IS THUS A SPORTING ELEMENT IN THE SPECIALITY; IT IS A GAME OF SKILL IN WHICH THE MORE ONE GRAPS THE RULES AND THE PROBABILITIES THE MORE ONE PLAYS IT WITH CHANCES OF SUCCESS.

—*G. A. H. Barton.*

AN EXPERIMENTAL INVESTIGATION OF THE PHARMACOLOGICAL ACTION OF NITROUS OXID . THE GASES INVOLVED . THE SYMPTOMS PRODUCED . THE ACTION OF NITROUS OXID UNDER VARYING CONDITIONS OF REBREATHING AND INSUFFICIENT OXYGEN . AN EXPERIMENTAL RESEARCH INTO THE NATURE OF NITROUS OXID AND ETHER ANESTHESIA WITH SPECIAL REFERENCE TO CERTAIN EFFECTS ON THE ORGANS OF THE BODY . THE RELATION OF INHALATION ANESTHESIA TO NORMAL SLEEP . THE INFLUENCE OF ETHER AND NITROUS OXID ON THE HISTOLOGIC STRUCTURE OF VARIOUS ORGANS . THE RELATION OF ETHER AND NITROUS OXID TO THE H ION CONCENTRATION OF THE BLOOD AND TO RESERVE ALKALINITY . THE RELATION OF ETHER AND NITROUS OXID TO INFECTIONS . THE CLINICAL BEARING OF THESE STUDIES . LIQUID AIR AND ELECTROLYTIC OXYGEN FOR ANESTHETIC PURPOSES . METHODS OF OXYGEN GENERATION . OXYGEN FOR MEDICAL PURPOSES . PRECAUTIONS . SOME VITAL STANDARDS OF PURITY.

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ADDRESSING THE Second Annual Meeting of the Interstate Association of Anesthetists, in Louisville, Ky., July 26-27, 1918, and publishing his researches in the International Journal of Orthodontia, Volume 2, No. 9, Dennis E. Jackson, now of Cincinnati, detailed his exhaustive experimental investigations of the pharmacological action of nitrous oxid as conducted in the Laboratory of Pharmacology, Washington University Medical School.

In the early days nitrous oxid was administered pure or almost pure, air being very generally excluded. This led to the production of asphyxia after a very brief period and thus the duration of the anesthesia was necessarily short. At a later period it was appreciated that a certain admixture of air with the gas was feasible and even often improved the character and extended the duration of the anesthesia. In 1868 E. Andrews of Chicago first used pure oxygen with nitrous oxid. This was a great advancement, which, although not generally appreciated at that time, has now come to be fully recognized as indispensable in the scientific administration of nitrous oxid.

Some months ago I devised a closed method for the administration of nitrous oxid and other anesthetics in conjunction with oxygen. I have used a number of different types of apparatus in connection with this method one of which has been described in a former publication.[1,2] My chief object in the present article is to discuss certain features of the pharmacological action of nitrous oxid as studied by this method. No morphin, scopolamin or other hypnotic has been used in any of the experiments herein reported.

I may refer briefly to an improved form of apparatus which I have used in these experiments

1. Jackson, D. E., Jour. Lab. and Clin. Med., 1916, Vol. i, p. 644.
2. Jackson, D. E.: Jour. Lab. and Clin. Med., 1915, Vol. i, p. 1.

(Fig. 1). A rotary pump of less capacity than that used in the device previously described is attached to a very much smaller and more compact frame. The chief object in this has been to simplify the apparatus and to reduce its size and weight. A number of valves, tubes and accessories shown in the illustration have been found by experience to be unnecessary, but in the experimental development of the device they were included as precautionary measures. The apparatus carries only two tanks, one for oxygen and one for nitrous oxid, for experience has shown that since tanks need to be renewed only at considerable intervals, and, if the breathing bag be filled moderately full at the moment when either tank becomes exhausted there will be ample time to remove the empty tank and replace it by a new one before a fresh supply of the gas (generally oxygen, of course) is required. Realizing the great value of simplicity and lightness in any form of apparatus intended for constant use, I

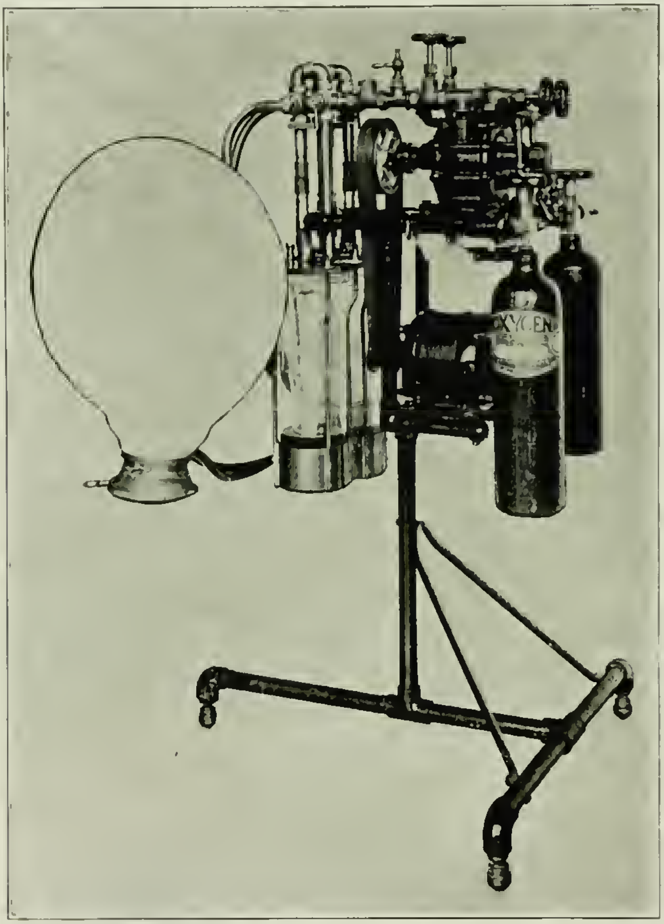

Fig. 1. Nitrous oxid apparatus with large bag as used for experimental purposes. (For discussion, see text.)

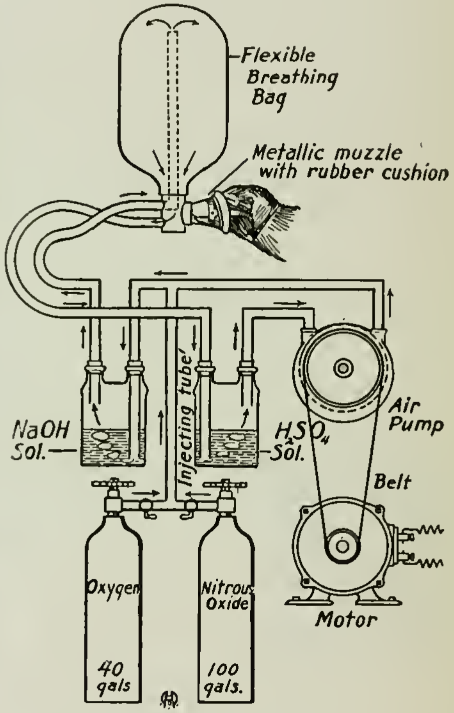

Fig. 2. Schematic diagram to explain the plan of construction of the apparatus shown in Fig. 1. The motor turns the rotary air pump which keeps the air (or gas and oxygen) circulating. (For discussion, see text.)

have spent much time and energy in trying to produce as simple a device as possible. It is perfectly evident that the apparatus here shown is much more complicated than it need be, but for the benefit of others who may be interested in the subject of nitrous oxid anesthesia, I have thought it worth while to include here an illustration of the apparatus with which much of the work discussed below has been carried out. For a detailed description of the general principles on which the device is operated I must refer the reader to the article indicated above. By further reference to the diagram shown in Fig. 2, it will be seen that by means of a motor and a rotary air pump, air or other gaseous or volatile substances (chiefly nitrous oxid and oxygen so far as the present article is concerned) are kept circulating within a closed system of tubes and vessels, and through a breathing bag into and out of which the animal breathes.

The vessels are two in number and consist of glass jars, the one containing sulphuric acid which serves to sterilize, dry and warm the air (or gases) which are washed through the acid, while the other jar contains sodium hydrate solution through which the air or gases, including the exhaled CO_2 from the patient are washed. The CO_2 is immediately absorbed by the sodium hydrate forming sodium carbonate and water according to the following equation:

$$2\,Na\,OH + CO_2 = Na_2\,CO_3 + H_2O.$$

The sodium carbonate being a soluble salt of course remains in solution (together with the H_2O formed) in the jar, the CO_2 being thus removed from the air (or nitrous oxid and oxygen) which the animal breathes. During this process the oxygen is consumed (250 to 300 cc. per minute for an adult man at rest) by the animal or patient. More oxygen is injected into the system from time to time in just such quantities as the animal actually consumes. The nitrous oxid, being a stable gas, is not broken down at all either by the animal or by the acid or sodium hydrate. Consequently there need be but little waste of the N_2O and only a small amount (experimentally I have estimated that from 1½ to 3 gallons will be necessary for a man weighing 160 pounds) is required to saturate the blood sufficiently to produce anesthesia. When a given amount of N_2O is injected into the closed system and breathing bag, the animal, whose lungs virtually form a part of the closed system, will at once begin to absorb N_2O into its blood from the pulmonary alveolar walls. This absorption goes on until an equilibrium in the quantity of N_2O contained in the animal's blood and tissues on the one side and that contained in the breathing bag and tubes on the other is established. It is important, however, to remember in this connection that the affinity of the blood and presumably of the central nervous system is greater for N_2O than is the affinity of water for N_2O. So far as is known at present N_2O does not form any special chemical combination with the blood or other tissues of the body. It is apparently held in solution in the blood and tissues in the same way as any other indifferent gas dissolves in a liquid, *i. e.,* in direct proportion to the partial pressure exerted by the gas on the liquid. The lipoid content of the blood and central nervous system is generally considered to account for the increased solubility of the gas in these tissues over that in water.

The breathing bag and face-piece shown in Fig. 1 are also modified considerably from that which I first used. The bag shown here I have found well adapted for experimental observations. It is chiefly from this standpoint that I want to discuss the action of nitrous oxid in this article. This bag holds three gallons, but the sides of the bag are flat and when not in use fall together as the air or gas passes out. When in use only about one or two gallons of air or gas need be injected into the bag and this permits the subject to have a full and free opportunity to breathe in any way he pleases. It is desirable that no excess pressure, as from an overfilled bag, be introduced to embarrass the breathing of the subject. The excess amount of work which may thus be easily thrown on the respiratory apparatus in the course of an hour may be astounding, as a brief mathematical calculation will readily show. And the problem is still further complicated both directly and indirectly by the embarrassment to the heart and lung circulation which the amount and peculiar application of this excess work involves. A further feature to be noted in the face-piece is the large opening, about three and one-half inches in diameter, which connects the bag to the air cushion resting on the face. Thus the subject breathes almost directly into the large flexible bag and obstruction of the respiration is reduced to a minimum. While this bag and face-piece serve very well for experimental observations, there are certain objections which may be made to them from a practical standpoint. The first of these is the difficulty of making an air-tight contact between the subject's face and the rubber cushion on the face-piece. The second is the inconvenience of having the large bag near the patient's head. At present, however, I wish to avoid any extensive discussion of the clinical side of this subject.

THE GASES INVOLVED IN NITROUS OXID ANESTHESIA.

THE PHARMACOLOGICAL RELATIONS of at least four gases must always be considered in nitrous oxid anesthesia. These are N_2O, oxygen, CO_2, and nitrogen. And it may be worth while to remember that a small amount of argon, neon, crypton and xenon are also present. Ordinarily these gases are supposed to be inactive in the animal organism, but under the peculiar conditions established in the gaseous content of the body under nitrous oxid anesthesia, I am inclined to believe that the presence of these substances, at least at the beginning of the anesthesia, should not be entirely forgotten.

It should be emphasized that the method which I have here used permits investigation of peculiar gaseous relationships which no other device heretofore employed for this purpose could well reveal. For by this method the supply of the four gases (N_2O, CO_2, N, and O) concerned in the animal's respiration may be separately and independently controlled. The CO_2, of course, is eliminated by the animal, but it may be allowed to accumulate in the breathing bag for experimental purposes and its relative action in combination with the other gases thus studied. The relative effects of CO_2 and O in ordinary forms of breathing and in asphyxia have been thoroughly studied by numerous investigators.[3] When, however, nitrous oxid is introduced, the conditions are very materially changed and only a small amount of work has been done on this phase of the problem.

It was supposed by Sir Humphrey Davy that nitrous oxid was decomposed in the body which thus became flooded with an excess of oxygen, which was promptly changed to carbon dioxid. This carbon dioxid then acted as a depressant and caused the anesthesia. It was later shown that nitrous oxid was not thus broken down but was excreted by the lungs in the same form as that in which it had been absorbed. The theory then became prevalent that nitrous oxid acted solely by excluding oxygen from the tissues and that its action was chiefly a matter of asphyxia. That asphyxia may, and in practice certainly does often play a considerable part during the production of the anesthesia, no one at present doubts. But it has been thoroughly established that nitrous oxid possesses distinct specific depressant powers of its own on the central nervous system. In 1897 Kemp[4] published a series of observations on the gaseous content of the blood during nitrous oxid anesthesia. He drew off blood from the femoral artery of dogs anesthetized with various mixtures of N_2O and air and of N_2O and O, and found that complete anesthesia could be produced by the gas when the blood contained quantities of oxygen fully capable of maintaining consciousness and of carrying on the ordinary process of metabolism. When nitrogen was substituted for the N_2O, the percentage of oxygen breathed remaining the same, the anesthesia gradually passed off and the animal regained consciousness. And it has been found by the late Sir Frederic W. Hewitt[5] that a mixture of nitrous oxid 80 per cent. and oxygen 20 per cent. (the amount present in air) is fully capable of producing anesthesia in suitable subjects. These observations prove beyond doubt that N_2O possesses specific depressant powers on the central nervous system. It has also been shown

3. HENDERSON, YANDELL: Jour. Amer. Med. Assn., 1914, April, p. 1133. Also DOUGLAS, C. G.: Literature in the Ergebnisse der Physiologie, 1914, Vol. xiv, p. 338.

4. KEMP, GEORGE: Brit. Med. Jour., 1897, Vol. ii, p. 1480.

5. HEWITT, F. W.: "Anesthetics and Their Administration," London, 1912, p. 312.

by Kemp as well as by others that under N_2O anesthesia the CO_2 content of the blood is greatly reduced below the normal. But in most cases, however, it has been found that the oxygen content of the blood is reduced in even still greater degree below the normal than is the carbon dioxid. As ordinarily administered N_2O causes the nitrogen (and presumably the argon, etc.) contained normally in solution in the blood and tissues to be rapidly washed out of the system. Kemp's blood analyses for the dog show in several experiments a complete absence of nitrogen from the gases drawn off by the vacuum pump. It is to be noted that in all other forms of anesthesia the nitrogen (about 1.7 vol. per cent.) remains dissolved in the blood. *Does the absence of this supposedly inactive gas in any way affect the anesthesia?* In many instances I have observed dogs going under the influence of N_2O in which it appeared to me very probable that the elimination of this nitrogen was essential to the production of successful nitrous oxid anesthesia. It is, unfortunately, extremely difficult to prove this point. For one must, as a general rule, empty out most of the air (nitrogen) from the apparatus (and lungs and tissues of the animal) in order to fill this space with nitrous oxid so as to be able to obtain a sufficiently high percentage of the gas to produce the anesthesia. This makes difficult the solution of the question as to whether or not the absence of the nitrogen in any way influences the nature of the anesthesia. In most forms of nitrous oxid apparatus used heretofore breathing had to be carried on under a greater or lesser degree of pressure. It is interesting to consider what influence, if any, this may have in tending to dam back the CO_2 produced in the tissues. While this gas did not apparently accumulate in large quantities in the blood in the analyses made by Kemp, still one is inclined to suspect that the tissues may have been trying to form the ordinary amounts of the gas but were either unable to do so or else they could not pass it over to the blood. And any such accumulation of CO_2 in the tissues may very well influence the nature of the anesthesia produced. And similarly any of the immediate precursors of CO_2, if allowed to accumulate in the tissues or blood, may affect the character of the anesthesia produced.

THE SYMPTOMS PRODUCED BY NITROUS OXID.

I HAVE STUDIED THIS topic both from the standpoint of animals and from that of man. A frog placed in an atmosphere containing a high percentage (90 to 98 per cent.) of N_2O becomes well anesthetized in from three to four minutes. When again placed in fresh air the animal fully recovers in about one minute. Profound anesthesia is readily obtained.

Fig. 3. This tracing shows the respiratory movements of a dog to which (at X) nitrous oxid (plus oxygen) was administered. There is a slight mechanical exaggeration of the respiration record because the animal had been breathing mainly with its diaphragm before the gas was given, but after this the chest movements became much increased. The stethograph recorded more of the thoracic movements than it did of the abdominal.

The symptoms in dogs vary greatly with the animal and the method of administration. Fig. 3 shows a record of the respiratory movements in a dog just beginning to inhale N_2O. The animal was lying quietly on the table and made no resistance in any way. The record was obtained by tying a stethograph around the chest wall and connecting it by rubber tubing to a recording tambour. The first part of the tracing shows the normal respiratory movements when the animal was breathing a sufficient percentage of oxygen and the CO_2 was not allowed to accumulate to excess. At the point indicated N_2O was run into the breathing bag and shortly thereafter the depth of the respiration began to increase. This is mainly due to the action of N_2O. It is the typical effect of this gas on the respiration. There is one other point to be considered in the experiment, however, and that is the fact that in this case when the N_2O was run into the bag then the oxygen which the bag contained was considerably diluted. This would also cause the animal to breathe more deeply. But independently of this dilution of the oxygen, the first effects of nitrous oxid in sufficient concentration appear to be to stimulate the respiratory center. After a time, as the animal passes more fully under the influence of the gas, the depth of the respiration decreases while the rate varies somewhat, but on the whole is accelerated beyond the normal. This does not seem to be due to any accumulation of CO_2 in the breathing bag or apparatus, for it is very easy to wash out the CO_2 as fast as it is formed. The animal usually does better, however, if a certain amount of rebreathing and CO_2 accumulation is permitted.

These same phenomena occur in the human subject. It is very interesting to experience the beginning action of the gas. If one fills the bag partly full of oxygen and breathes this for a while (washing out the CO_2), he may at first note a very slight sense of fullness in the head and possibly there may be a feeble flushing of the skin, especially of the face and neck. Whether this is due to a slight CO_2 accumulation in the lungs (dead space, etc.), caused by the small amount of obstruction to the normal respiration, or is due entirely to excitement or the mere feeling that one *expects something* I have not been able to determine. It is of but little consequence, however, and soon passes off as one adjusts himself to breathing into and out of the bag. Slight odors, as from a new rubber bag, or of oil from the pump, sometimes cause one to be a little apprehensive. And the mere act of fixing the attention on the respiration is sufficient to cause certain minor variations in most subjects. When the N_2O is turned on, however, there is an immediate feeling of ease in breathing. The sensation can best be compared to the effect of oiling a new machine. One is somewhat surprised how readily he can breathe deeply and fully and without special exertion. This sensation does not occur if one instead of running nitrous oxid into the bag, should fill it to a corresponding degree with oxygen. I have been inclined to believe, therefore, that it is due to a direct stimulation of the respiratory center by the N_2O. I have considered the question of whether or not the processes of diffusion of the gases in the lungs, or the rate or ease of absorption or excretion of the oxygen or CO_2 through the alveolar epithelium might be influenced in any way by the presence of N_2O rather than of nitrogen. I have not been able to reach any conclusion on these matters. It seems probable that certain obscure changes are produced in the metabolism of the tissues on account of the subnormal CO_2 and oxygen content of the blood, as shown by Kemp. It would be interesting to know whether or not these low percentages of CO_2 and oxygen persist in the blood in those cases in which anesthesia is produced by approximately 80 per cent. N_2O and 20 per cent. oxygen as in Hewitt's experiments. I have occasionally believed that in rare instances in dogs which were fully anesthetized I could raise the percentage of oxygen in the bag to perhaps 30 per cent. without allowing the animal to revive. In this case, of course, while I might markedly increase the percentage of oxygen in the bag, I did not correspondingly lessen the amount of N_2O in the animal and in the apparatus. In this feature there is a great difference between the apparatus which I have here used and most other forms of nitrous oxid machines, for in these if the amount of oxygen administered is increased, this generally means a *corresponding diminution of the amount of N_2O given with correspondingly increased chances for variations in the character of the anesthesia.*

I have noted only occasionally, as have a number of my students, that just as one begins to breathe a fairly concentrated mixture of N_2O there may be detected a faint metallic sweetish taste on the tip of the tongue. The sensation reminds one of the taste of saccharin. In my own case this taste has never lasted for more than a second or two, but one student was able to detect it over a prolonged period. It is probably due to N_2O carried in the blood from the lungs to the taste organs.

It will be noted from Fig. 3 that the animal did not struggle as the gas was administered. In some cases I have seen dogs go quietly to sleep and apparently never be conscious at all that they were being anesthetized. In a gentle animal which is especially susceptible to the gas, this may frequently occur. It is by no means the rule, however, and there is often struggling especially if the animal was excited before the anesthesia was started. It is well known that certain human subjects are especially resistant to the gas and I have frequently found this to be true for dogs. In some cases I have been entirely unable to obtain any true anesthesia at all. In these cases cardiac slowing and other complications nearly always come on as one attempts to crowd the gas. This appears to be partly due to stimulation of the vagus center in the medulla for section of the vagi usually accelerates the heart and this is generally even more marked after atropin. I have seen three or four especially striking cases of this kind. An animal which is excited or struggles is much more liable to manifest these cardiac symptoms. After atropin the animal usually takes the gas considerably better, indicating better aeration of the blood in the lungs from the improved circulation. The slowing of the heart may be very marked and apparently may be the cause of death in some cases. I have not taken string galvanometer tracings of the hearts of these animals, but this would be instructive. It has seemed to me in one or two instances that peculiar arrhythmical contractions were set up in the heart and that this finally ended suddenly either with complete stoppage of the heart, or with the establishment of a condition resembling heart block. The cause of these reactions is not at all clear. One would suspect a lack of oxygen, or CO_2 poisoning, but when the CO_2 is well washed out of the gases breathed and the conditions are the same as those under which other animals have been well anesthetized, then one is inclined to look for a difference in the animals. I suspect that very nearly, if not quite this same thing, may have occurred in a few instances in man.[6] For that reason I wish to refer briefly to Fig. 4, which is a tracing of the apex beat of a dog which was given nitrous oxid. The animal was not a good subject, but was finally apparently well anesthetized. After the anesthesia had continued for perhaps half an hour, the pulse in the femoral artery became irregular and finally stopped rather suddenly. With considerable difficulty the animal was re-

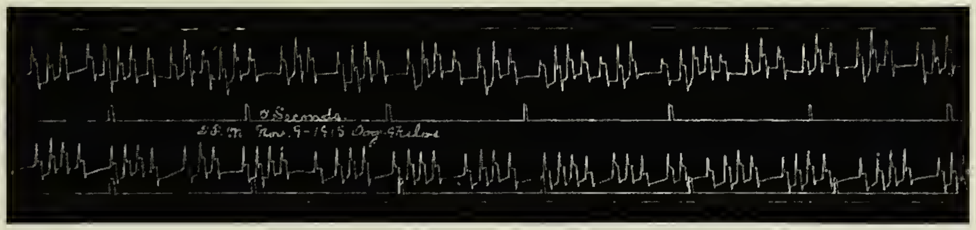

Fig. 4. Tracings of the apex of the heart in a dog in which under nitrous oxid anesthesia cardiac irregularities developed. For a full description, see text. This tracing was taken about five hours after the animal had been anesthetized. At this time it was observed by Mr. John A. Higgins that the animal was in a dazed or semi-comatose condition, and that the heart beat was very abnormal. The record here shown was then made.

6. See Robinson, G. Canby: "Transient Auricular Fibrillation in a Healthy Man Following Hydrogen Sulphide Poisoning," Jour. Amer. Med. Assn., 1916, May 20, p. 1611. See also Willett and Tyrrell (2 cases): The Lancet, London, 1902, March 29, p. 897. In both of these cases I suspect cardiac irregularities were present.

vived by means of intermittent compression of the chest. But when the respiration was restored, the animal did not promptly regain consciousness and remained in a semi-comatose or somnolent condition for two or three hours. It was noticed about five hours after the animal revived that the heart was irregular and the tracing here shown was made. The animal improved, and in about a week the heart had apparently returned to normal. The animal was kept for forty days thereafter, but no further cardiac disturbance was observed.

It seems evident to me that the human subject must be very much more susceptible to nitrous oxid than is the average dog. The anesthesia in all cases is of a much lighter form than that produced by ether. In dogs it is as a rule impossible to destroy the corneal reflex, for in the deepest anesthesia in these animals the slighest touch of the cornea or eyelid or even eyelashes causes immediate winking. The eyes remain open and keep up peculiar rolling or staring movements so that one often wonders whether or not the animal is fully anesthetized. If the gas be removed suddenly, however, the animal wakes up and stares about in a way which shows that it had been completely unconscious. During the anesthesia the pupils are dilated but the light reflex is preserved.

THE ACTION OF NITROUS OXID UNDER VARYING CONDITIONS.

If PURE N_2O BE inhaled, unconsciousness results in a period of from thirty to sixty seconds. But if oxygen be added to the inhaled gas, the time required to produce unconsciousness rapidly increases as the oxygen rises from zero up to five, ten or more per cent. With more than ten or twelve per cent. oxygen content mixture of nitrous oxid and oxygen usually produce unconsciousness only after considerable periods or not at all, depending on the patient. There seem to be great variations in this respect, however, in the human subject, and I have noted a similar reaction in animals. I should like to emphasize this point in particular since it has a direct bearing on the administration of nitrous oxid by the method which I have here used.

It will be noted by reference to Figs. 1 and 2 that there is a considerable *dead space* in the apparatus. The wash jars, tubes, pump, and the breathing bag all represent space which in the beginning contains air. When the animal is connected to the apparatus then its lungs also add *dead space* to the system. This *dead space* contains oxygen and nitrogen. The oxygen can be readily used up by the animal, but the nitrogen must be gotten rid of. The amount of this nitrogen depends on the construction and size of the apparatus and on the size of the animal. The blood (and tissues) of the animal also contain about 1.7 per cent. of nitrogen which presumably diffuses out into the lungs and is then breathed out when nitrous oxid and oxygen are administered. It is necessary to remove a large part of this nitrogen from the apparatus to secure the best success. This is done by filling the bag partly full of nitrous oxid and running the pump for a while. The animal breathes the mixture of air and N_2O and absorbs a portion of the gas, while at the same time some of the nitrogen in its blood is breathed out. The sodium solution and the sulphuric acid in the wash jars also absorb some nitrous oxid. In a little while the bag is emptied out into the air. This is accomplished by opening a valve on the right (positive) side of the machine while the pump is running. In one or two seconds the bag can be emptied as much as desired and then more N_2O is run in until the bag is about one-half or two-thirds full. This is repeated about three or four times as a rule with dogs. One should not hurry this process. It usually takes at least five minutes to anesthetize a dog deeply and any attempt to crowd the gas faster generally excites the animal and does not improve the anesthesia. It is better to proceed slowly and allow the animal's blood to become as nearly saturated as possible for each concentration of the N_2O. In this manner the action of the drug is brought on slowly and in a perfectly successful experiment the animal may be fully anesthetized apparently without being conscious that anything unusual is occurring. Often it is not necessary to give any oxygen until the animal is anesthetized, for the oxygen in the apparatus and in the lungs serves to keep the animal in good condition for some time. When needed, however, more oxygen should be injected.

It may seem that five minutes is an unreasonably long time to require for the production of nitrous oxid anestheia. We should remember, however, that much more time than this may be required with ether, and when we think of anesthetizing an animal in thirty to fifty seconds with nitrous oxid it is interesting to consider the possibility of doing this same thing with chloroform or ether vapor which are exceedingly well absorbed by the blood. And it is probable that in any rapidly produced nitrous oxid anesthesia there may be a considerable element of asphyxia which is undesirable.

In this connection I should like to refer to some physiological experiments[7] on respiration which involve certain features usually concerned in nitrous oxid anesthesia.

"1. *The Immediate Effects of Total Rebreathing (Due Chiefly to Excess Carbon Dioxid).*—The nostrils are compressed with a nose-clip and the subject breathes from and into a rubber bag containing 20 to 40 liters of air. The amplitude of respiration is soon augmented, and in the course of a few minutes the subject is panting heavily forty times a minute. He usually develops a typical carbon dioxid headache, but this wears off in fifteen or twenty minutes after the experiment is ended." These results are produced by breathing for a *few minutes* into a closed bag. If in addition to these effects, which are due chiefly to carbon dioxid accumulation, there be added the further effects of oxygen want which are usually present from the very beginning in the administration of nitrous oxid, what will be the results of these purely physiological phenomena when complicated by the addition of nitrous oxid in those forms of apparatus in which rebreathing into and out of a closed bag is carried on for considerable periods of time?

"2. *The Effects of Insufficient Oxygen Without Excess of Carbon Dioxid.*—The above-mentioned bag is refilled with 20 to 40 liters of fresh air and the experiment performed again, but with this difference, that a vessel of 1 or 2 liters capacity filled with soda-lime or broken sticks of sodium hydrate is placed between the bag and the subject's mouth so that he breathes through it into and from the bag. The carbon dioxid exhaled by the subject is thus absorbed, and he gradually consumes the oxygen in the bag. As a rule there is *no noticeable deepening or quickening of the breathing,* and the subject will first become cyanosed and then unconscious without appreciable augmentation of breathing. This experiment should *always be carefully supervised,* as it is not free from danger. If continued for more than ten minutes, it is usually followed by a severe frontal headache, developing slowly for several hours thereafter, together with other ill effects and lasting from twenty-four to forty-eight hours." It is particularly interesting to consider this experiment in connection with those forms of nitrous oxid apparatus in which the patient inhales the gas (plus a varying but usually small amount of oxygen) from a tank or reservoir and then exhales out into the open air. In these machines the carbon dioxid is probably fairly completely removed as fast as it is exhaled from the lungs. The small percentage of oxygen usually given (*e. g.*, from two to ten or twelve per cent.) with the nitrous oxid may cause a rather close simulation of the conditions established in the above experiment in which *cyanosis* and *unconsciousness* may be produced *without any anesthetic.* I should like to give one further quotation bearing on the point from Haldane and Poulton.[8] * * * "Still more sudden exposures to anoxemia occur when air containing little or no oxygen is breathed; for in this case the oxygen previously present in the alveolar air, and even in the venous blood, is rapidly washed out; the result is that consciousness is suddenly lost

7. Henderson, Yandell: Jour. Amer. Med. Assn., 1914, April 11, p. 1134.

8. Haldane, J. S., and Poulton, E. P.: Jour. Physiology, 1908, Vol. xxxvii, p. 401.

without evident preceding hyperpnea, although abundance of CO_2 is present in the arterial blood. Haldane and Lorrain Smith observed sudden loss of consciousness after 50 seconds on breathing air which was afterwards found to contain 1.8 per cent. of oxygen. During any exertion the loss of consciousness is still more sudden. This is a common experience with miners going into an atmosphere of nearly pure fire damp (CH_4), or climbing up so that their heads are in the gas, that they drop suddenly as if they were shot."

I do not care to discuss this point further, but may state briefly that my own experiments, together with the results obtained by others, have led me to conclude that it is impossible to obtain a rapid (1 minute) production of anesthesia and unconsciousness in dogs with nitrous oxid and oxygen at atmospheric pressure unless the oxygen content of the mixture is so low that the loss of consciousness is due *almost entirely* to the lack of oxygen. Presumably, with certain modifications, this is true in the human subject also. On the other hand it seems probable that in all dogs which do not possess a special idiosyncrasy against the gas, mixtures of nitrous and oxid and oxygen containing sufficient amounts of the latter to avoid most if not all asphyxial effects, may be used to produce anesthesia *provided sufficient time be allowed for the gas to act and the CO_2 be completely removed as fast as it is excreted by the lungs.* If a high per cent. of oxygen is used, anesthesia cannot be quickly produced but asphyxia may be avoided. The time required may be considerable, perhaps from five to fifteen minutes or longer. But as the tissues gradually become more and more saturated with the gas, there will be a gradual depression of the central nervous system which will finally result in unconsciousness.

It was long ago observed by Goldstein[9] that anesthesia appears more quickly and with a proportionately less degree of asphyxia, the higher the organization of the brain—namely, earlier in man than in laboratory animals. I have been able to confirm this observation many times. And in addition the anesthesia appears as a general rule to be deeper in man than in dogs, although in some animals a profound anesthesia may be readily obtained if all carbon dioxid effects be carefully avoided.

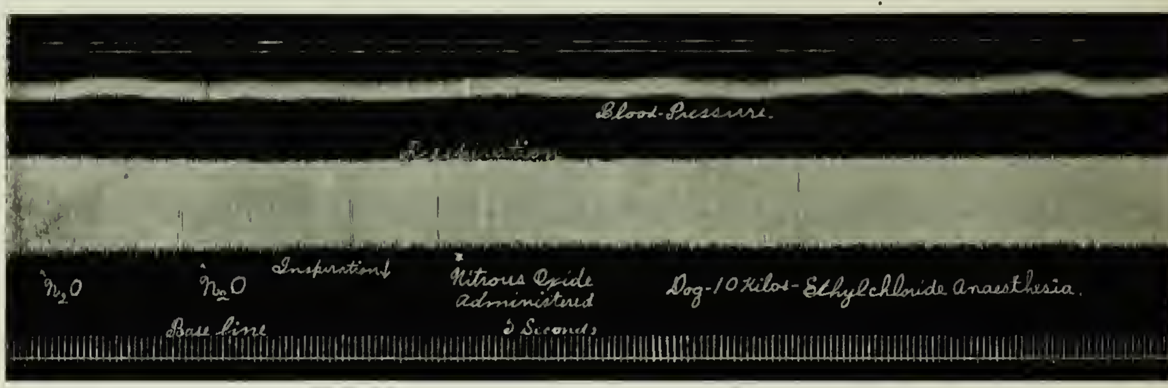

Fig. 5. Blood pressure and respiration in a dog anesthetized with ethyl chlorid. At three places, as shown on the record, nitrous oxid was run into the breathing bag. This was done in order to observe the effects of the gas on the circulation and respiration. The results were practically nil so far as can be observed from the record.

It seems probable that in average cases the heart and circulation are not much affected by the gas. Fig. 5 shows the result produced by injecting nitrous oxid into the breathing bag when the animal was already anesthetized by ethyl chlorid. Three injections were made but the effects on both blood pressure and respiration

9. See Gwathmey: "Anesthesia," New York, 1914, p. 127. Brunn: "Die Allegemeinnarkose," Stuttgart, 1913, p. 327.

were practically nil. This corresponds very well to the injection of an ordinary drug solution into the femoral vein when an animal is anesthetized with ether. (Fig. 6 shows the reverse of this experiment and illustrates the action of ethyl chlorid on an animal already anesthetized by nitrous oxid.) As a kind of check on these experiments another tracing (Fig. 7) is shown in which at two places a small amount of carbon dioxid was injected from a tank into the breathing bag. There is an immediate stimulation of the respiration and the blood pressure falls, probably from a direct action on the heart. The gas was quickly emptied out and the bag was again refilled with nitrous oxid plus a suitable amount of oxygen. This shows quite well the action of even small amounts of carbon dioxid. I strongly suspect that some such action as this, either by excess of carbon dioxid, or from lack of oxygen, or both, constitutes the real cause of the undesirable after-effects which are liable to follow from prolonged nitrous oxid anesthesia. And I am inclined to believe that these after-effects may be very generally avoided by a correct and scientific administration of nitrous oxid.

Fig. 6. This animal was anesthetized with nitrous oxid. At the point indicated ethyl chlorid was injected into the bag. There is an immediate fall in pressure and the respiration is much diminished.

I have repeatedly observed, as have others, independently in my laboratory, that if one breathes a mixture of nitrous oxid and oxygen for a certain time, for example five minutes, and then passes under the influence of the gas to a given

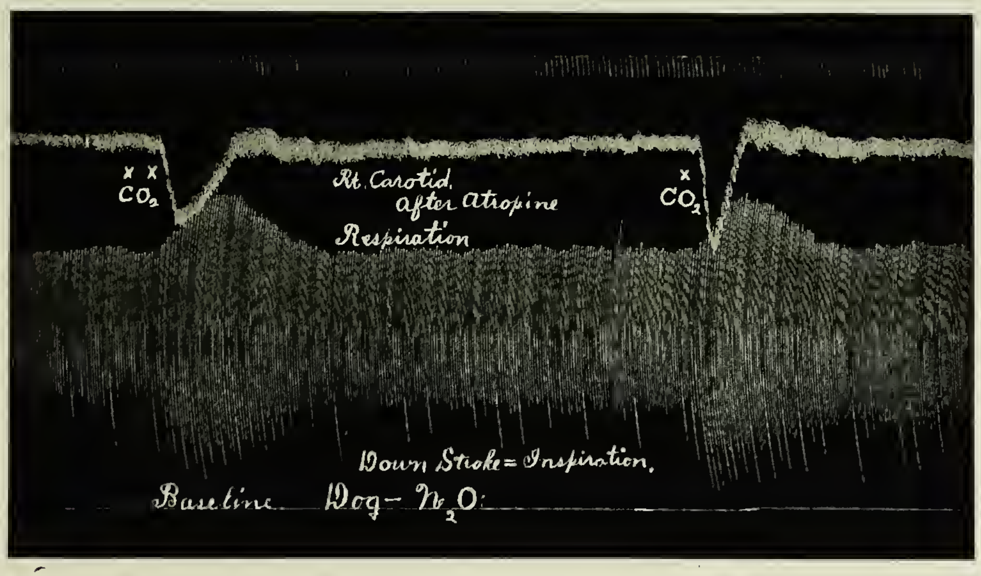

Fig. 7. This tracing was made in a class experiment by Messrs. Mitchell, Day, Lucking and McKee. It shows the results produced on the respiration and blood pressure by injecting (twice) a small amount of carbon dioxid into the breathing bag while the dog was anesthetized by nitrous oxid. In each case the CO_2 was quickly emptied out of the bag after the animal began to show marked symptoms.

degree, he can then considerably increase the quantity of oxygen in the bag without lessening the influence of the nitrous oxid so far as the subject of the experiment himself can determine. The reason for this appears to be as follows: On breathing the N_2O at first the whole body of the subject after a time becomes saturated with the gas at the given partial pressure. (As the first portion of gas is absorbed, one can see the bag shrink fairly rapidly with animals.) More N_2O must be run into the bag to replace that absorbed. But after the anesthesia or analgesia has reached a given degree, then if no more gas, but only oxygen, is given, the effects of the N_2O on the subject should remain fairly constant. It will be noted that the gas is excreted only into the bag from which in a given time approximately the same quantity of N_2O will pass back again into the blood. Supposing the bag was filled to the amount of two gallons (for clearness of description I have assumed that the *volume* of one gallon of the gas may be considered equal to the volume of four quarts. We need not consider variations of temperature, pressure, etc.) with 90 per cent. N_2O and 10 per cent. oxygen. If then one adds a quart of oxygen to the bag the per cent. of oxygen the patient would breathe should be increased by one-ninth of the total amount of mixed gases in the bag after the quart of oxygen is added. It would appear that this oxygen should be readily absorbed by the lungs in approximately the same proportion and quantity as oxygen is absorbed by the blood from the air (which contains oxygen in about the same proportion as the bag would now contain it, *i. e.*, about 20 per cent). This would probably not be quite correct, for nitrous oxid has some power to displace oxygen from its solution in water (Sir

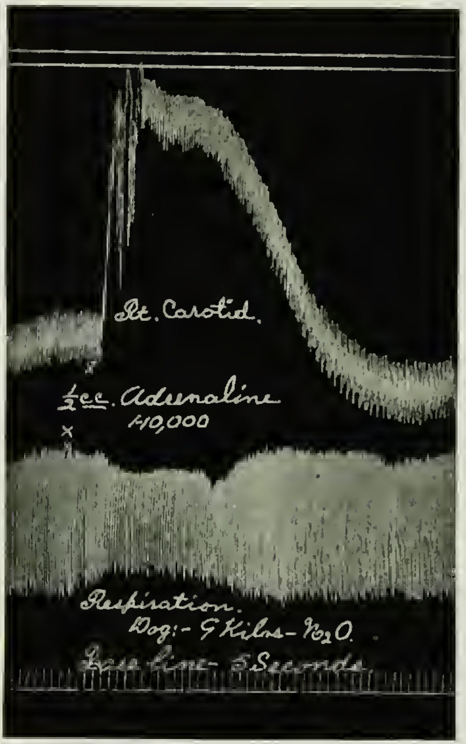

Fig. 8. The animal was anesthetized with nitrous oxid. At the point indicated adrenalin (½ cc. 1-10,000) was injected intravenously. The vagi were intact. (For discussion, see text.)

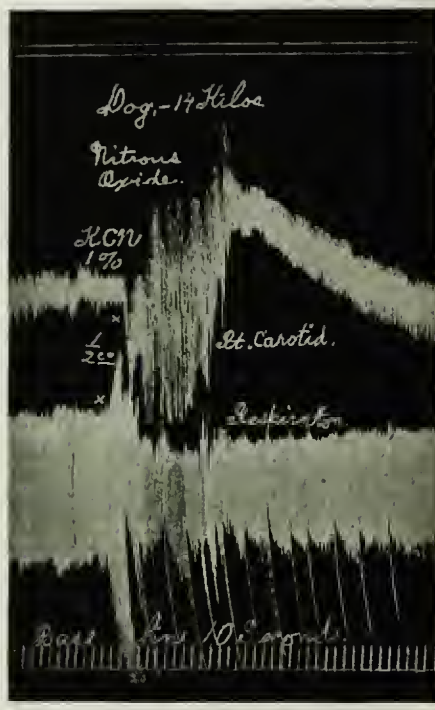

Fig. 9. Dog anesthetized with nitrous oxid. At the point indicated ½ cc. of 1 per cent. KCN was injected intravenously. The vagi were intact. (For discussion, see text.)

Humphrey Davy[10]), and this probably holds good for the blood in the pulmonary capillaries also. On the other hand, when the quart of oxygen is run into the bag, the latter will be expanded by a volume equal to one quart and into this space the nitrous oxid already in the bag and also that dissolved in the blood and tissues of the subject, may diffuse. But if, for example, the blood and

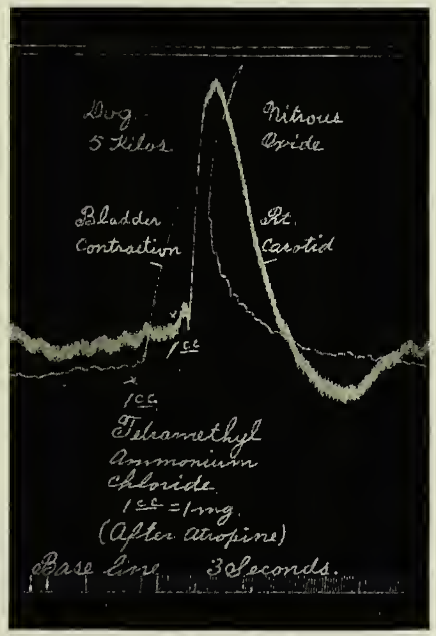

Fig. 10. Dog anesthetized with nitrous oxid. The tracing show the blood pressure (Rt. carotid) and the bladder contractions (up-stroke). At the point indicated 1 cc. of tetramethylammoniumchlorid was injected intravenously. The animal had previously received 1½ mgs. of atropin.

tissues of the subject had absorbed two gallons of N_2O and the bag contained two and one-fourth gallons of (mixed) gases after the quart of oxygen was added, then there would be a chance for the N_2O to be diluted by approximately one-seventeenth of the total volume of gases or 5.8 per cent. At that time the subject might be breathing almost 20 per cent. of oxygen and this is readily absorbed by the hemoglobin of the blood. In other words, the relative increase in percentage of oxygen breathed when a given amount of oxygen is added to the bag, is greater than is the relative amount of dilution of the nitrous oxid with which the subject is saturated after the oxygen is added to the bag.

10. Hewitt, Sir Frederic W.: "Anesthetics," London, 1912, p. 91.

It was shown by Van Arsdale[11] in 1891 that the breathing of nitrous oxid to and fro from a bag in which the gas (plus the desired amount of oxygen) was contained at an increased pressure above that of the atmosphere caused an in-

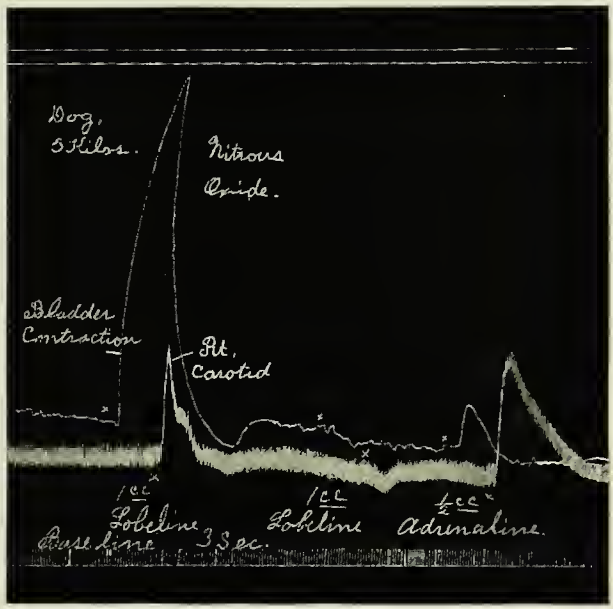

Fig. 11. Dog under nitrous oxid anesthesia. Bladder contractions (up-stroke) and blood pressure. At the point indicated (on the left) 1 cc. of lobelin was given intravenously. A marked contraction of the baldder and a small rise in blood pressure were produced. A little later a second dose of 1 cc. of lobelin was given. Almost no results were produced by this, showing that the first dose of lobelin had produced ganglionic paralysis. Later a small dose (½ cc.) of adrenalin was injected. This gave a slight bladder contraction and a small rise in blood pressure.

crease in the depth of the narcosis produced. (This was an entirely different principle from that which Paul Bert[12] and later Claude Martin[13] used in which the patient or animal was placed in an air-tight room, the air pressure in which was raised one-fourth above that of the atmos-

11. Van Arsdale, William Waldo: Amer. Jour. Med. Sc., 1891, Vol. cii, p. 142.

12. Bert, Paul: Comptes rendus, 1879, Vol. lxxxvii, No. 20, p. 728. Also Vol. xcvi, p. 1271.

13. Martin, Claude: Comptes rendus, 1888, Vol. cvi, p. 290. Also L'Union Médicale, 3 sér, 45, 1888.

phere after which 80 per cent. N_2O plus 20 per cent. oxygen was administered to the patient or animal.) I have tried to verify Van Arsdale's results many times. In some cases (with dogs) increasing the pressure of the gas in the bag does deepen the anesthesia, but in many other cases I have not been able to demonstrate any advantage from this increased pressure. Perhaps the increased respiratory exertion, the marked hindrance to the pulmonary circulation and the attendant obstruction of gaseous exchange in the lungs were sufficient in many cases to overcome the advantages of the increase in absorption of the N_2O which the raised pressure might bring about.

The intravenous injection of adrenalin in an animal under nitrous oxid anesthesia gives a practically normal reaction, *i. e.*, the record is almost exactly like that produced by adrenalin in an animal under ether. The rise in pressure here probably supplies more oxygen to the brain and whatever asphyxia may have been present from the administration of the nitrous oxid is thereby reduced (see Fig. 8). On the other hand, the injection of cyanides (which are supposed to cause an internal asphyxia by lessening the tissue oxidations through inhibiting ferment action) causes a markedly increased reaction both as regards the respiration and the circulation. The animal also shows a more marked convulsive reaction than it does under ether (see Fig. 9). I have controlled this by anesthetizing the animal first with N_2O and obtaining records of the blood pressure and respiration from the cyanides and then giving the animal ether, after which more records were obtained.

The motor areas are much more sensitive under nitrous oxid than under ether. One can easily secure very extensive movements of the muscles of the opposite side and can readily pick out the areas for individual groups of muscles. I have observed that dogs under nitrous oxid anesthesia may not well withstand extensive operations, particularly if the abdomen is opened and the viscera manipulated in any way.

In several respects there is a striking similarity between the effects of nitrous oxid and those of morphin in dogs. Among these may be mentioned the production of Cheyne-Stokes respiration. This is generally present in prolonged anesthesia in dogs. The irritability of the cord is also much less depressed than is the case with the methane series of anesthetics and this action also closely resembles that of morphin. As under morphin defecation also sometimes occurs, but I have generally been inclined to attribute this to asphyxia, although other factors may be involved. A peculiar feature is often noticed in the fact that the dogs, while lying quietly and apparently fairly well anesthetized, may be aroused and waked up by stimulation or shaking in a manner very similar to that possible under a moderate dose of morphin. When thus aroused there is also often observed a marked acceleration and increase in the strength of the heart beat. If the animal be again left alone it will soon return into the somnolent, or perhaps analgesic state, very much as occurs after morphin. It is difficult to study the analgesic effect of nitrous oxid separately and apart from the production of total unconsciousness in dogs, for these animals, so long as they are conscious, are very likely to struggle and try to escape even though they feel no pain whatsoever.

The thought has occurred to me many times that nitrous oxid might be used as a hypnotic. By ordinary methods of administration this is obviously impractical. But by a slight modification of the apparatus which I have used I am inclined to believe this idea might be very well put into practice. I have tried repeatedly to compare the mild on-coming effects of the gas as breathed with a considerable proportion of oxygen with the physical and mental sensations present as one begins to fall asleep. There is a very striking similarity, a marked feeling of tiredness and exhaustion, the limbs feel heavy and the eyelids tend to close. One's mentality gradually sinks and there is difficulty in maintaining connected thought. The natural inclination of the subject of the experiment is to lie down quietly and fall asleep. The sensations remind one of the feelings of a child worn out by a long day's play when it lies down at night to sleep. Sometimes I have noted slight muscular twitchings or feeble jumping or convulsive movements. These would probably not occur if the gas were administered very slowly with plenty of oxygen and a sufficiently long period of time were used to bring on the action of the drug. Suggestion appears to play a noticeable part in this action, for if one keeps perfectly quiet and at rest and tries to go to sleep, then the somnolent action of the gas is especially liable to be well marked. It would appear that this matter of suggestion extends even to dogs. For an animal which is petted and induced to lie down quietly and at complete rest may very often take the gas readily and peacefully fall asleep.

GEORGE W. CRILE, of Cleveland, Ohio, speaking during the Fourth Annual Meeting of the American Association of Anesthetists, in Detroit, Michigan, June 12, 1916, and later publishing his views in the Anesthesia Supplement of the American Journal of Surgery, emphasized the similarity of safe anesthesia to sleep, and compared the relative action of nitrous oxid and ether on various organs, the H ion concentration and infections as worked out in the Laboratories of Western Reserve University Medical School and in the clinics of Lakeside Hospital.

If we view man and the lower animals as adaptive mechanisms, governed by the universal laws of physics and chemistry, then we must believe that every phase of human or animal behavior is occasioned by and in turn occasions physical and chemical changes in the body. Therefore an understanding of the vast alterations in the behavior of the anesthetized organism—changes which may range from the slightest depression of mental power through progressively deeper stages of unconsciousness to death, necessitates a search for the physical and chemical changes caused by the anesthetic. Accordingly, in this study we shall consider (a) the gross behavior of the anesthetized individual in a consideration of the relation of anesthesia to normal sleep; (b) the influence of ether and of nitrous oxid on the histologic structure of certain organs; (c) the relation of ether and of nitrous oxid to the hydrogen ion concentration of the blood and to reserve alkalinity; (d) the relation of ether and of nitrous oxid to the infections; and finally, (e) the clinical bearing of these studies.

THE RELATION OF INHALATION ANESTHESIA TO NORMAL SLEEP.

THE OUTWARD SIMILARITY in the appearance of sleep and of anesthesia needs no comment. The manner in which a child becomes unconscious under a sufficiently concentrated flow of nitrous oxid over its face closely resembles the manner in which the healthy normal child falls asleep. That sleep is merely the depression of consciousness and that sleep only partially suspends the function of the brain is indicated by slight responses to stimuli, such as the shifting of posture; moving when called or when bright light strikes the eye; the response to tickling, or other reflexes. In other words, the receptors are still active during sleep. The activity of the receptors in anesthesia is evidenced as clearly by the increased pulse and respiration in response to trauma; and, if the anesthesia be light, by increased muscular tone, even by muscular movements. Another similarity is found in the resemblance between dreams during nitrous oxid anesthesia and the dreams of normal sleep.

THE INFLUENCE OF ETHER AND NITROUS OXID ON THE HISTOLOGIC STRUCTURE OF VARIOUS ORGANS.

AS FAR AS NITROUS OXID is concerned, here also is found another resemblance to normal sleep. During normal sleep the histologic changes in the brain, the adrenals and the liver due to exertion, emotion, infection and acid injection, are repaired; during nitrous oxid anesthesia also the lesions in the brain cells due to these causes are repaired, and as will be seen later, nitrous oxid exerts a measurably protective action on the adrenals and liver as well. This protective action of nitrous oxid was strikingly demonstrated in a series of experiments on insomnia. A group of rabbits were kept awake continuously for approximately 100 hours. At the end of this period, their brain cells showed the typical physical changes of exhaustion. In another group these changes were partially restored after a single seance of sleep; while in still another group, in which the rabbits were allowed no normal sleep, but were placed under nitrous oxid anesthesia for one hour out of every six during a period of approximately 100 hours, the brain cells, as in the rabbits allowed to sleep, showed marked restoration, some cells indeed being in a *plus normal state*.

A comparative study of the effects of ether and of nitrous oxid was made by keeping dogs under continuous anesthesia for four hours. After four hours continuous ether anesthesia, striking histologic changes were found in the brain, the adrenals and the liver; while after four hours continuous nitrous oxid anesthesia, there were practically no changes in the brain and but slight changes in the liver and adrenals.

THE RELATION OF ETHER AND OF NITROUS OXID TO THE H ION CONCENTRATION OF THE BLOOD AND TO RESERVE ALKALINITY.

IN A SERIES OF H ion concentration tests made for me by Dr. M. L. Menten, it was found that the H ion concentration of the blood was increased by ether and by nitrous oxid; that the acidity increased more rapidly under nitrous oxid than under ether, but that the total acidity in either case was proportional to the depth of anesthesia. (See Year-Book, 1915-1916.)

In measurements of the reserve alkalinity of the blood made for me by Dr. W. B. Rogers, he found that during anesthesia the reserve alkalinity gradually decreased, the total decrease being greater under ether than under nitrous oxid. He found also that the alkalinity of the spinal fluid and of the bile was altered during anesthesia.

It is significant to note here the fact that the histologic lesions in the brain, the adrenals and the liver, caused by ether and by nitrous oxid, though varying in degree, are identical in kind with those caused by the intravenous injection of acids, as with those resulting from insomnia, exertion, emotions, infection or physical injury.

We must conclude, therefore, that the histologic lesions of inhalation anesthesia are acid lesions; and since acid lesions are restored only during sleep, that the same must be true of the lesions of anesthesia.

As long as fifteen years ago, it was believed that all anesthetics interfered with the use of oxygen, this being the method by which anesthesia was produced. It is true that deep asphyxia may cause anesthesia, but in such asphyxia as is due to obstruction of the larynx, the patient remains conscious and feels pain, though he is markedly cyanotic. While under good inhalation anesthesia, the patient is pink and unconscious. It would seem, therefore, that interference with oxidation alone is an insufficient explanation of anesthesia. On the other hand, the postulate that anesthesia is an induced acidity is not only supported by the laboratory studies we have mentioned, but by the clinical phenomena of anesthesia as well.

It may be in place to refer here to Lillie's notable studies of the mechanism of ether anesthesia. He has demonstrated that the addition of ether to the seawater in which Arenicola are living caused changes in the semi-permeable membranes, as a result of which these membranes become less permeable to the passage of ions. As life itself is dependent upon the permeability of the cells of the organism to the passage of ions, this action of ether suggests a further explanation of anesthesia, though its application has not been worked out in detail. (See Year-Book, 1915-1916, 1-30.)

THE RELATION OF ETHER AND OF NITROUS OXID TO THE INFECTIONS.

WE HAVE ALREADY referred to the protective action of nitrous oxid in the presence of the stimuli of continued consciousness as in prolonged insomnia; and other histologic studies have shown that morphin also protects the brain, adrenals and liver from the destructive action of prolonged or intense stimuli. It follows, then, that since the effects of an infection upon the brain, adrenals and liver are identical with the effects of insomnia and emotion, then the administration of nitrous oxid and morphia will in part protect the organism against the damaging effect of infection.

Our experimental findings may be summarized as follows: Nitrous oxid and ether anesthesia alike cause an increase in the H ion concentration of the blood, the spinal fluid and the bile; and progressively decrease the reserve alkalinity of the blood. Ether causes marked histologic changes in the brain, adrenals and liver, these changes being identical in kind with the histologic lesions caused by acid injection, or activation of any kind. Nitrous oxid and morphin each measurably protect the brain against histologic changes due to infection, while ether increases the damaging effects of infection.

THE CLINICAL BEARING OF THESE STUDIES.

THE IDENTITY OF the phenomena of anesthesia with the succession of clinical symptoms which accompanies an increasing acidosis combined with the fact that the histologic changes produced by nitrous oxid and by ether are identical with those caused by acidosis, supports the postulate that anesthesia is an induced acidity. If the acidity is slight, anesthesia is light and the patient responds to even slight stimulation. As the acidity increases, the anesthesia deepens—first, associative memory is lost, but the cutting of the skin still causes involuntary movements; then muscular tone is lost and even the strong contact stimuli of a surgical operation cannot drive their impulses through the brain to the muscles; and finally, the decreasing alkalinity may so nearly approach the neutral point that even the circulatory and respiratory centers, which are especially adapted to respond to the stimulus of increased H ion concentration, fail to respond; respiration and circulation are suspended and acid death—*anesthetic death* follows.

These studies explain why a patient, whose reserve alkalinity has been seriously reduced by exertion, emotion or physical injury, or infection; or by reason of starvation, interference with respiration or impairment of the liver or kidneys, is approaching acidosis, and does not take an inhalation anesthetic well; why there is much nausea and slow recovery from anesthesia in some cases and death in others; why children in particular, who are near acidosis, always pass into that state and die unexpectedly.

These facts show how necessary it is for the surgeon and the anesthetist alike to realize that during the operation each is draining the store of reserve alkalinity. If the surgeon employs a local anesthetic, uses gentle manipulation and produces the least possible trauma, he conserves his patient and demands from the anesthetist less of the damaging inhalation anesthetic. The anesthetist in turn conserves the patient by using the lightest possible even anesthesia administered with the least psychic trauma.

These studies show that for the bad risk nitrous oxid anesthesia is to be preferred to ether and that analgesia with local anesthesia should be employed, with general anesthesia only when it is demanded by certain phases of the operation.

These researches suggest the value of a mechanistic view of the phenomena of anesthesia and attach a high importance to the work of the anesthetist.

In my own clinic we have now administered nitrous oxid anesthesia in just under 15,000 cases without a death; and moreover, as our knowledge and experience accumulate, we are able with increasing accuracy to adapt the anesthetic to the individual.

THE INCREASING DEMAND for oxygen in connection with various anesthetic agents, rescue work as well as its use in the treatment of disease makes it imperative that we should look carefully to our oxygen supply as to its purity. Presenting this matter before the Joint Meeting of the Interstate Association of Anesthetists and the Mississippi Valley Medical Association, at Toledo, O., October 9-11, 1917, C. C. McLean, of Dayton, O., suggested that:

The increasing demand for oxygen in connection with various anesthetic agents, rescue work of various kinds as well as its use in the treatment of disease, makes it imperative that we should look carefully to our oxygen supply as to its purity.

The ever-increasing price of oxygen for medicinal purposes, the increasing supply for commercial purposes with the great variation in cost, have led some of us to do a little thinking which has resulted in articles being prepared, read and published; and when we read in these articles that oxygen sells from $1.50 to $50 per hundred cubic feet we wonder where we are and when the game is going to stop. A saving of $48.50 on 100 cubic feet or about 700 gallons of oxygen is an item that most of us cannot afford to overlook.

Before we proceed to buy a cheap oxygen for medicinal purposes let us go a step farther and investigate the reason for the variation in price.

METHODS OF OXYGEN GENERATION.

THE ADVENT OF WELDING by the oxy-hydrogen and oxy-acetylene processes made the production of oxygen a commercial problem and we know that meant an oxygen produced at a cost that could be used at a profit.

Oxygen generation is of three classes, chemical, electrolytic and atmospheric, to each of which except the second there are subdivisions.

The chemical oxygen cannot be produced at a profit for commercial purposes; this is not true of electrolytic and atmospheric methods.

Can commercial oxygen be used for medical purposes?

OXYGEN FOR MEDICAL PURPOSES.

THIS IS THE QUESTION that confronts us and the answer will give us some information as to the great difference in cost that we note in some of the articles that are published.

We will first consider chemical oxygen. The most common chemical process is the dry evolution of oxygen under the influence of heat from a mixture of 100 parts by weight of crystallized chlorate of potash and 13 parts of manganese dioxid. contained in a sealed retort. The gas requires thorough washing in a sodution of caustic soda to eliminate its chlorin. The fault with most chemical processes is the difficulty of eliminating the poisonous chlorin.

Electrolytic oxygen is produced by a group of oxy-hydrogen generators, each an electrolytic cell through which, by the passing of an electric current, water containing some alkali is decomposed. The oxygen collects at the positive electrode and the hydrogen at the negative electrode.

The two gases, as they collect on their repective electrodes, are effectively separated, and the bubbles rising as they collect are entrapped in compartments. The gases pass into pipe lines and thence into gas holders. A compressor removes the gases from the holders and pumps them into cylinders.

The impurity in electrolytic oxygen is hydrogen.

Atmospheric oxygen is produced by various methods. Those in use in America are the Linde or German method and the Claude or French method.

The air is compressed to a liquid, then submitted to a process of rectification at the same time that an almost complete transference of heat is obtained from the compressed air entering the apparatus to the liquid air thus formed.

The air is compressed by a four-stage compressor and after each stage the heat of compression is removed by passing the air through a cooler, through which water is circulated. The carbon dioxid and moisture in the air are readily eliminated by freezing and the oxygen becomes liquid while the nitrogen is still gaseous.

This explains in brief the principle of the separation of the gases.

The impurity in atmospheric oxygen is nitrogen.

PRECAUTIONS.

WE FIND THE IMPURITIES to be hydrogen in electrolytic oxygen and nitrogen in liquid air and both hydrogen and nitrogen are inert gases and are harmless in the quantities in which they are found, but we must not jump at the conclusion that we can go to any plant producing commercial oxygen and procure our supply without first ascertaining if the plant is prepared to furnish oxygen in cylinders that are used only for medicinal purposes, as cylinders that are used for commercial purposes may at some time have been used for other gases that would render the oxygen unfit for medicinal purposes.

Again proper precautions may not have been taken in the production of the gas, while it would not injure it for commercial use, would render it unfit for our work.

Any commercial plant can be equipped to produce oxygen for medical use, but it will have to add the cost of equipment and analysis to insure to the consumer a pure gas, just the same as we demand chemically pure drugs and would not use a commercial article for medical purposes.

We must also remember that the price of commercial oxygen that is quoted as 2 cents a cubic foot or 2/7 cents a gallon means at the plant and does not take into consideration the added expense of drayage, freight and middleman.

Those of us that are fortunate enough to live near a commercial plant that will produce an oxygen that will come up to the following requirements will greatly reduce the cost and have an article that is safe for internal use.

STANDARDS OF PURITY.

STANDARDS OF PURITY recommended by Charles Baskerville and Reston Stevenson for oxygen to be used in the machine:

The gas should be neutral toward moist, delicate litmus paper; and when passed through an aqueous solution of silver nitrate it should produce no turbidity. Not more than an opalescence should be produced when two liters of the gas are passed slowly through an aqueous solution of barium hydroxid. When five liters of the gas are passed slowly through an aqueous solution of sodium hydroxid, then over heated copper oxid, and finally through an aqueous solution of barium hydroxid, no turbidity should be produced. The gas should contain at least 94 per cent. oxygen upon the dry basis. As supplied for use, the gas should contain no liquids and no solids.

WE MAY ALL BE JUSTLY PROUD OF THE REALIZATION OF OUR PLANS, WHEN WHAT HAS FIRST BEEN ONLY A DREAM STANDS BEFORE US—A DREAM COME TRUE. CHILDREN DELIGHT IN PLAYTHINGS THEY HAVE FASHIONED WITH THEIR OWN HANDS. WE ARE ALL BORN TO BE PRODUCERS, TO ADD TO THE WEALTH AND BEAUTY AND HAPPINESS OF THE WORLD. OUR GIFT NEED NOT BE AN OBELISK BY THE NILE, OR A PARTHENON OR THE DOME OF A ST. PETER'S. A CHEERING WORD THAT HEARTENS A BROTHER FOR THE DAY'S STRUGGLE—THAT, TOO, BUILDS FOR ETERNITY IN THE SOULS OF THOSE WHO GIVE AND THOSE WHO RECEIVE.

—*Meredith Nicholson.*

BEFORE OPERATION THE ANESTHETIST, AS WELL AS THE SURGEON, SHOULD MAKE HIMSELF FAMILIAR WITH THE CONDITION OF THE HEART, KIDNEYS, BLOOD PRESSURE, HEMOGLOBIN AND ANY UNUSUAL CONDITION; SHOULD SEE THAT THE MOUTH, TONGUE, TEETH AND TONSILS ARE IN PROPER CONDITION AND THAT PROVISION BE MADE TO PREVENT CHILLING OF THE PATIENT, AN IMPORTANT POINT NEVER TO BE OVERLOOKED. DURING OPERATION THE ANESTHETIST SHOULD ATTEND STRICTLY TO HIS OWN BUSINESS. HE SHOULD GLANCE AT THE OPERATION ONLY FROM TIME TO TIME, NOT TO STUDY THE OPERATION, BUT TO ANTICIPATE THE NEED FOR LIGHTER OR DEEPER ANESTHESIA OR TO DETERMINE WHEN THE ANESTHESIA MAY BE STOPPED. OF COURSE HE SHOULD KEEP HIMSELF CONSTANTLY INFORMED OF THE GENERAL CONDITION OF THE PATIENT BY OBSERVATION OF THE RESPIRATION, THE MOST IMPORTANT FUNCTION OF ALL, OF THE BLOOD PRESSURE, PULSE, PUPIL, COLOR AND CONDITION OF THE SKIN AS TO SWEATING. I AM PERSUADED THAT THE USE OF AN ANESTHESIA CHART IN EVERY CASE TENDS TO CONCENTRATE THE ATTENTION OF THE ANESTHETIST UPON HIS JOB AND TO MAKE HIM MORE CAREFUL. IN A FEW YEARS SUCH CHARTS WOULD FURNISH US WITH VERY VALUABLE AND EXTENSIVE STATISTICS. INSTEAD OF DISTRACTING THE ATTENTION FROM THE PATIENT THESE RECORDS FIX THE ATTENTION OF THE ANESTHETIST MUCH MORE CLOSELY UPON THE CONDITION OF THE PATIENT THAN IF NO CHART IS USED. OBSERVATION AND CHARTING OF THE BLOOD PRESSURE NOT ONLY BEFOREHAND, BUT AT FREQUENT INTERVALS DURING EVERY IMPORTANT OR PROLONGED OPERATION, ESPECIALLY AS A GUIDE TO THE DEGREE OF SHOCK, IS ESSENTIAL FOR SAFETY. ACCURATELY KNOWN BLOOD PRESSURE IS OF GREATER VALUE THAN THE RATE AND QUALITY OF THE PULSE AND GIVES WARNING FROM FIVE TO TWENTY MINUTES EARLIER THAN THE PULSE. IN ORDER THAT MEDICAL MEN AND WOMEN SHALL DEVOTE THEMSELVES TO ANESTHESIA AS A SPECIALTY, THE PUBLIC MUST BE TAUGHT THAT SAFETY LIES IN HAVING AN EXPERT ANESTHETIST, AND THAT LIKE ANY OTHER EXPERT, IF HE IS TO OBTAIN A LIVING AS SUCH HE MUST BE WELL PAID, OTHERWISE HE CANNOT DEVOTE HIS WHOLE TIME TO THE SPECIALTY.

—W W Keen.

ORAL AND SINUS SURGERY UNDER NITROUS OXID-OXYGEN ANESTHESIA IN THE FORWARD INCLINED SITTING POSTURE GENERAL CONSIDERATIONS THE ALVEOLAR PROCESSES, TONSILS AND SINUSES AS POINTS OF INFECTION . NECESSITY FOR THOROUGH ROUTINE EXAMINATIONS . SURGERY OF THE SINUSES . TONSIL OPERATIONS . ADVANTAGES OF THE SITTING POSTURE . TONSILLECTOMY IN THE UPRIGHT POSTURE . STAGES OF THE OPERATION . ETHER ADMINISTRATION IN THE UPRIGHT POSTURE . REACTION OF THE CONSCIOUS PATIENT TO RESPIRATORY EMBARRASSMENT . THE ANESTHETIST'S TRADITIONAL MANAGEMENT OF RESPIRATORY EMBARRASSMENT . ARTIFICIAL RESPIRATION . THE THEORY OF ANEMIA OF THE BRAIN . THE COMMON OBJECT OF ARTIFICIAL RESPIRATION . ROLE OF THE HEART . ADVANTAGES OF THE UPRIGHT POSTURE TO OPERATOR AND ANESTHETIST.

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E. I. McKESSON, M. D. — EX.-PRES. INTERSTATE ANESTHETISTS — TOLEDO, OHIO.
W. H. ROBERTS, M. D. — AM. LARYNGO-RHINO-OTOLOGICAL SOC — PASADENA, CAL.
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SPEAKING BEFORE a Joint Meeting of the Interstate Association of Anesthetists and the National Dental Association, at Louisville, Ky., July 26-27, 1916, and publishing their observations in the Journal of the National Dental Association, 1916, Ira O. Denman and E. I. McKesson, of Toledo, O., emphasize the value of the forward inclined sitting posture for oral and sinus surgery under nitrous oxid-oxygen anesthesia. These authorities assert that:

Philosophize as we may upon the mystery of human life; speculate and theorize upon the plan of existence; be we orthodox or evolutionists, the predominant fact is, that we are here on earth for an indefinite period, and that our residence here is pleasurable and profitable or the contrary, according to numerous conditions in and about us.

The range and variation of the human race are so great that there are but few things common to all men. Some one said that the six feet of earth is the common level, but before that state is reached there is a proposition upon which all men, great and small, rich and poor, learned and unlearned, may unite, and that is that good health is the greatest blessing of life. Health is more to be desired than anything else in the world. True, it must often be impaired or lost in order to be appreciated, but, when lost, its regaining becomes the supreme object in life. Fortunes, great and small are laid down at its shrine. Sickness and death are terms which strike terror to the hearts of all men. Nature's strongest instinct is self-preservation. It pervades all form of life. To it is due the perpetuation of all life. This instinct is predominant in the human species. We call the antithesis of health, disease. The guardian of health and the relentless foe of disease is the physician.

If, then, it is given to us—and I beg to be understood to include under the term *physicians* all who labor in the field—under whatsoever heading—be it internist, dentist, anesthetist, surgeon, ophthalmologist, laryngologist, or the family doctor; if, as I say, it is given to us to foster and protect the thing of supreme value to all classes of people—should we not feel proud of our calling, and see that such pride is not unmixed with a due sense of grave responsibility which assume to our fellowmen upon donning the mantle of the greatest of all professions.

GENERAL CONSIDERATIONS.

THE AGE OF TRULY great progress and scientific accomplishment in medicine and surgery dates from the discovery of anesthesia and bacteria. True, there are many diseases which are not due to bacterial action, but in this discussion we shall only consider those conditions which arise from infections, and some of their surgical requirements. Again, we find a division of infections as to their origin, either within or without the body, into exogenous and endogenous.

In recent years we have heard much of focal infections, and today we are endeavoring to measure their far-reaching effects and to cope with some of them surgically.

The profession generally owes much to the dental pathologist for his pioneer discoveries and invaluable contributions to this very important question. In fact, I wish that I might pause here and pay a fitting tribute to the American dentist, who so far outshines his European colleague as the sun does the moon. Whose prowess no longer lies in the celerity with which he can separate one from his *ivories*, in which age his highest ambition was to become notorious as the *lightning dentist*, but who now seeks to excel in prophylaxis, and finds his chief delight in preserving to us that which his predecessor could only extract.

May I say, further, that to my mind the dentist is really a specialist in the field of medicine and surgery, having in his special care the oral cavity —the gateway to the alimentary and respiratory tracts and so of infinite importance.

The almost marvelous progress of dental science in America is better realized when we reflect that less than two centuries ago the blacksmith was the tooth extractor, while the barber honed his razor to perform phlebotomy, from which practice the modern tonsorial sign gets its blood-red stripes.

Only recently the writer was told by a guide in Boston of the versatility of Paul Revere, who, before his famous ride, had achieved local prominence through his skill as a silversmith, goldsmith, coppersmith, blacksmith and dentist.

The anesthetist called in upon those occasions is not described, nor even mentioned, but no doubt he or they were the Jess Willards and Frank Gotchs of that period. No less striking contrast is presented in the field of anesthesia, from the patient being brutally held upon the table by pugilistic strength, to the calm, peaceful slumber for hours, if need be, under modern scientifically controlled anesthesia—represents the two extremes.

The surgeon must be mindful of the invaluable assistance of the anesthetist to whose achievements in his field surgery owes so much.

THE ALVEOLAR PROCESSES, TONSILS AND SINUSES AS POINTS OF INFECTION.

RETURNING TO OUR SUBJECT, we know that in points of lowered resistance occur culture beds for bacteria. Some locations for these are the alveolar processes; the tonsils and the nasal accessory sinuses. Pathogenic micro-organisms here find the requisites for their propagation—warmth, moisture and pabulum—when such points become veritable hotbeds for the breeding of disease.

The infection invades the lymph and blood currents, polluting the same, and the vital organs are thus supplied by a devitalized and impoverished stream. In time the individual's health is impaired, either by a general inefficiency of the bodily functions or by the direct entrance of some definite disease.

This is the age of sanitation and prophylaxis in medicine. The whole trend of scientific endeavor is towards prevention rather than cure of disease. A gigantic wave of instruction to the laity, such as the world has never seen, is now sweeping over the country, teaching the people how to keep well. Columns appear daily and weekly in the public press, and these silent monitors do much in the humblest homes to diffuse the light of knowledge concerning the paramount issue. Much of such literature properly conveys to its readers the essentials of pure air, sunlight, good food, proper clothing, exercise, clean streets and alleys and good drainage.

More minutely must we show them that in addition there are great dangers to be found within their own bodies. There are hidden foes —focal points of infection within the tonsils, sinuses and in the gums—which cause many diseases, such as rheumatism, endocarditis and tuberculosis, and we must *clean house* by eliminating from our own bodies such hotbeds for bacterial growth.

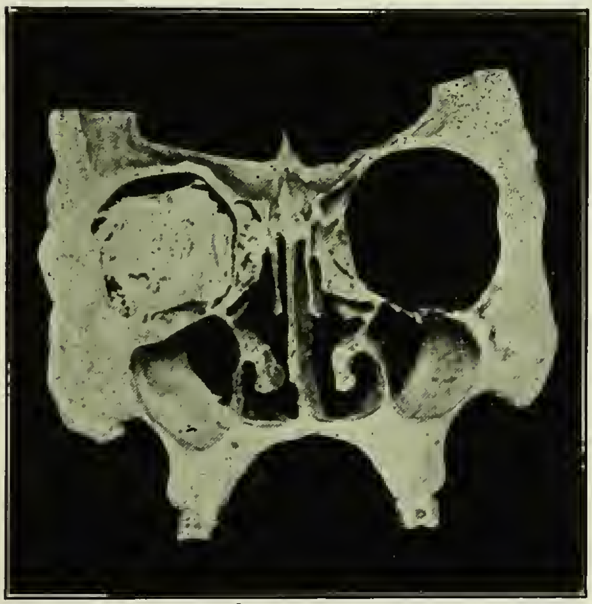

Fig. 2. Cross-section of the bones of the face, normal specimen. Note the wide, free passage between the central walls and the middle turbinated body and septum.

NECESSITY FOR THOROUGH ROUTINE EXAMINATIONS.

MODERN SURGICAL METHODS, under modern anesthesia, may, as it were, pluck the thorn from the flesh and not only lengthen the span of human life, but make for greater efficiency, health and happiness while we abide.

A well-known internist states emphatically that *"the removal of the focus of infection is demanded as a fundamental principle in the treatment of systemic diseases of the chronic type,"* and, farther, *"to the now well-known relation of focal infections as a chief factor in the etiology of acute rheumatism, chronic deforming arthritis, gonorrheal arthritis, malignant endocarditis, myositis, myocarditis, septicemia of various bacterial types, tuberculosis, nephritis and visceral degeneration, we may add certain infectious types of thyroiditis, with or without hyperthyroidism, pancreatitis, acute and chronic, with or without resulting glycosuria, peptic, gastric and duodenal ulcer and cholecystitis."*

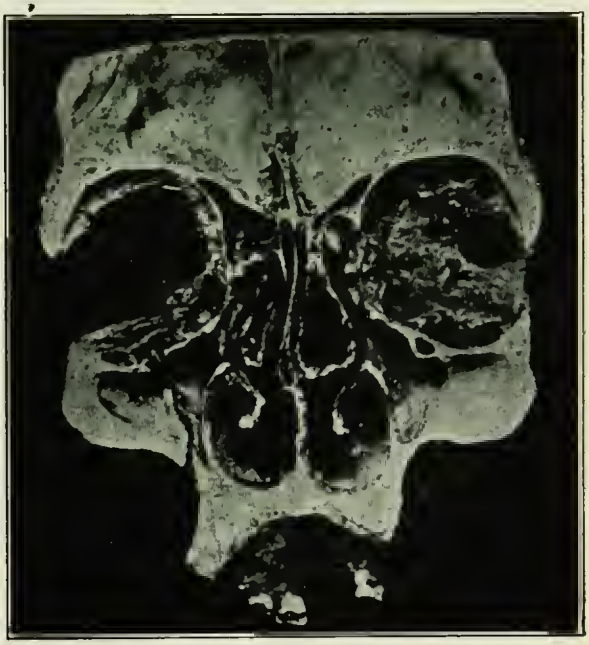

Fig. 3. Cross-section showing a large middle turbinated bone which occludes the maxillary sinus ostium. This turbinate is hollow, containing an accessory ethmoid cell, and is a congenital malformation.

Unfortunately, the recognition or diagnosis of the focal infection is not always an easy matter. If it were true that its presence were always a subjective manifestation, then more often would they be detected. On the contrary, however, there are often absolutely no local symptoms, such as pain or soreness, and thus insiduously is the patient's health undermined.

Alveolar abscesses are often unrecognized by the patient, and only film roentgenograms disclose their presence. Chronic sinusitis may exist for years unknown, and a large percentage of chronic tonsillar infections, which are so extensive as to ruin the health, frequently give no rise to sore throat.

The treatment of focal infections is essentially surgical, either to establish drainage and ventilation or to extirpate the infected tissue. I shall gladly omit those renal, appendiceal and other foci belonging to the general surgeon, from this paper. Neither shall I presume to discuss those of the alveolar processes before this body, but I shall limit my remarks to the sinuses and tonsils, which are of interest to dentist and rhinologist alike.

SURGERY OF THE SINUSES.

THE NASAL ACCESSORY SINUSES are the frontal, ethmoidal, sphenoidal and the maxillary or the antrum of Highmore. Physiologically they act as an auxiliary to the nose in supplying moisture to the air we breathe. They also increase the resonance of the voice and strengthen and lighten the bones of the face. These cavities depend upon two things for their hygienic state: ventilation and drainage. Any deformity, injury or disease within the nose which interferes with the ventilation or drainage may prove to be the cause of an acute or chronic sinusitis. The ostia, or openings of all these sinuses, except the sphenoid, are found in one vital area of the nose; this is the hiatus semi-lunaris, or the uncinate groove, beneath the middle turbinated bodies. This is called the *vicious circle* of the nose. It is here that most trouble often originates. Anything, such as septal deflections, congenital deformities, either of the septum or of the middle turbinate, or chronic catarrhal enlargements of the turbinated or new growths, polypoid usually in character, may obstruct the nasal ostia of the sinuses at this point. Such obstructions, if long continued, may result in chronic sinusitis. The ethmoids are usually the first affected, and the next the frontal, then the maxillary, and the sphenoid least of all.

The maxillary sinus, by reason of its peculiar position relative to the *vicious circle* being below it, and having its natural opening on a level with its roof, is by its natural formation particularly susceptible to infections which gravitate into it from one or both of the sinuses situated above. Drainage is unfavorable from it because the secretions have to run uphill, as it were, to the ostium. Infected material, therefore, may be imprisoned in this cavity, which is a veritable trap for the dregs from the nose and other sinuses. At the most dependent portion of this sinus, and thus where the toxic matter would be expected to gravitate and remain, we find the roots of the teeth penetrate into the antrum cavity. These roots are covered only by mucous membrane. With this anatomy, dental surgeons are quite familiar, but dental pathologists have been too generous in accepting the majority of the responsibility for antrum infections, claiming as high as 75 per cent. of such cases arise from dental infections. That some cases do owe their origin to a primary dental-caries which break through into the antrum, there is no doubt. However, allow me to repeat that the maxillary sinus is an accessory nasal cavity having a natural opening into the nose, and not an accessory oral cavity. I have personally never seen a case of abscess of the antrum which did not present some signs of co-existing intranasal infection. Furthermore, given a case of chronic antrum infection, where there has been retention of toxic material for a long time, this material gravitating to the most dependent portion, which is the location where the roots of the teeth penetrate, I ask, is it not possible, or at least reasonable, to expect that such teeth may become infected *from* the antrum, and thus reverse the supposed order? Therefore, I wish to take the advanced position of relieving the dentist of much of the responsibility for the disease in this sinus, believing that dental infections are often secondary to nasal infections in this region.

TONSIL OPERATIONS.

WHETHER OR NOT THIS SUGGESTION meets with your approval, my next statement must go unchallenged, and that is, that the average dentist fails to take advantage of the opportunity daily afforded him to be a leader in the field of prophylaxis, so far as certain focal infections are concerned. Too often he thinks only of the alveolar foci. He should realize that his opportunity to discover also both sinus and tonsillar disease is almost enviable.

He sees diseased tonsils daily. He can, with the aid of a nasal speculum, see disease within the nose also daily. The nasal speculum should be a part of every dentist's equipment, and no dental examination should conclude without the inspection of the nose and also the tonsils, not only as a diagnostic, but as a prognostic measure.

Fig. 4 Cross-section showing a deflected septum, which partially obstructs the drainage and ventilation of the sinuses.

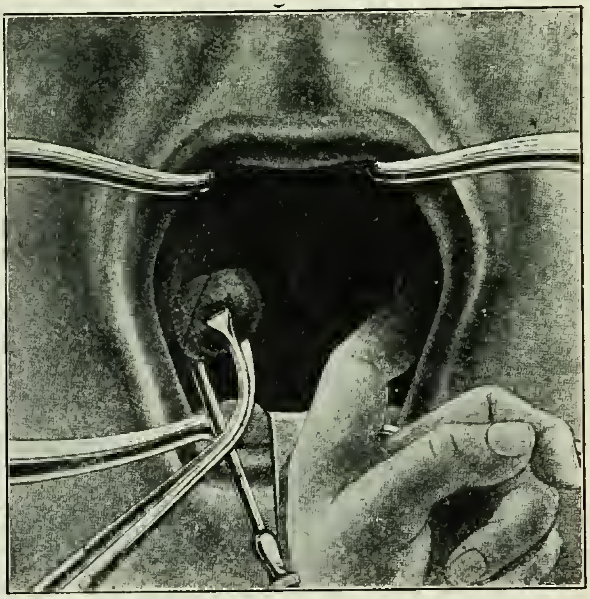

Fig. 5. The author's tonsillectomy. A second tenaculum and snare are applied when the finger completes the dissection and both tonsils are simultaneously removed.

It is my deep conviction that the intent of all surgical operations should be to restore the parts as nearly to the normal state as possible, with the least disfiguration in sinus work, keeping in mind a statement made earlier in this paper, that the health of the sinuses depends upon drainage and ventilation; these we should first restore to a diseased sinus, with the minimum amount of the destruction of tissue.

I decry the wholesale disfiguring external operations of radical sinus surgery, and plead for conservative assistance to Mother Nature by intranasal procedures wherever such means give any promise of relief. No external mutilation of a patient's face is justifiable until after other measures have failed, and the removal of a sound tooth to secure drainage should not be the first procedure.

Intranasally, the region of the middle turbinate must be cleared and freed from pressure so that the sinus ostia may remain open. The middle turbinate must often be partially or wholly removed, septal deflections straightened, polypi removed and diseased ethmoid cells opened for drainage or removed if necrotic.

Surgery of the maxillary sinus, a subject in itself, can only be briefly mentioned. Freeing the natural opening alone is sufficent in many cases. This, together with a counter opening in the naso-antral wall beneath the lower turbinal, sometimes removing a portion of the antrum end of the same, cures the great majority of cases. Some chronic cases with granulations, polypi and septi require a larger opening in the sinus wall to permit curettage and ocular inspection. For this there have been a number of methods proposed. Experience proves that the more the antrum is left as an accessory nasal cavity, that is, the smaller the opening in the naso-antral wall, the better. Large openings permit irritating substances from the air to maintain a constant irritation of the sinus lining membrane.

For the surgical treatment of nasal and sinus affections, I prefer nitrous oxid-oxygen anesthesia in the forward inclined sitting position, to be described later.

The tonsil is, without doubt, the greatest offender in the whole field of focal infections. Tonsil tissues, especially after the activity of the gland ceases in early childhood, furnish a most fertile culture bed for micro-organisms. Unlike most other locations, the focus is here accessible and permits of direct ocular inspection. Unlike sinus and alveolar processes, which permit only of drainage followed by therapeutic measures to restore the parts to a normal condition, in the case of the tonsil, the whole disease mass is easily removed, thus eliminating at once from the body the source of toxemia. Unfortunately, we meet an issue in the tonsil question which is not encountered in any other infected region—not even now in appendicitis—the teleological question. Every day I am asked: "Why does Nature give us tonsils if they are not for some use?" and "Should they not be treated and retained?" and "If a portion of the tonsil only is diseased, why remove the whole gland?" This last question is propounded also by physicians, and some specialists still advocate a tonsillotomy, at least they perform that operation.

An attempt to answer these questions here would be an imposition upon your patience, as it would mean opening up a question the discussion of which is almost as voluminous as was that regarding the appendix two decades past. The following statements, however, are regarded by the writer as facts, after careful observation: First, the tonsil function, if it has any, is performed and concluded early in life. Its activity ceases by the eighth to the twelfth year, after which its decline begins and its tissues are incapable of repair. Second, like the man who says a thing cannot be done, is interrupted by someone else doing it, so those who declare that tonsillectomy should not be performed are confronted constantly by its beneficial effects. I am speaking, of course, of diseased tonsils only which, through careful inspection by lifting the submerged tonsil out of its bed (and it is this variety most often diseased), an accurate diagnosis can be made. After the thorough removal of all tonsil tissue in its capsule, we note a certain and rapid improvement in health in every case.

To say, therefore, that tonsillectomy is overdone, simply because it is done frequently, is unwarranted. To say that it is poorly done, that it is attempted by men unfamiliar with its anatomical structure and surroundings, whose technic is faulty, and whose skill is unequal to the surgical requirements of the case, by men who are unable to cope with complications should they arise; whose instruments, anesthetic position and method are conductive to only a partial removal of the tonsil tissue, together with more or less mutilation of the delicate throat and palatal muscles, would be a broad statement, but, if true, would account largely for the general dread of the tonsil operations, and also for the continued ill health in certain cases, owing to the retention of diseased tissue.

That there are certain dangers in tonsillectomy cannot be denied. It is always a major operation, preparation for it should be in keeping with those of major surgical operations. It is always a hospital operation.

ADVANTAGES OF THE SITTING POSTURE.

IT IS THE FIRM CONVICTION of the writer that the common dangers can be avoided. Among these dangers are the anesthetic, asphyxiation from inspired blood and secretion, hemorrhage and shock.

The anesthetic of choice is nitrous oxid-oxygen. It is not profoundly toxic, such as chloroform or ether. Anesthesia is quickly induced. Its administration may be continuous, permitting an uninterrupted surgical procedure. There is absence of mucous secretions. Pure oxygen quickly awakens the patient, simultaneously checking any bleeding. There is no nausea following and it is altogether not an unpleasant experience for the patient.

Inspiration of blood and secretion into the lungs is an immediate danger to the patient by asphyxiation, and a remote cause of pulmonary sepsis, pneumonia and death. Various positions, such as hanging the head downward, placing the patient on the side, and various aspirators and suction pumps have been devised, in attempts to exclude these secretions from the larynx, trachea and lungs, for bear in mind that only in nasal or oral surgery, including exodontia, does blood *per se* become a danger factor. A patient can drown from a much smaller quantity of blood inspired. To avoid this danger in nasal and oral surgery, I have in my technic called to my assistance a great natural force—the force of gravity. I place the patient in such position as to allow all secretions to flow outward and downward out of the mouth or nose—the forward suspended sitting posture. A special chair is used, capable of attaining this position with all ages and sizes of patients. The operator's stool is quite low, so that the illumination from his head lamp is directed well upward. The patient's body leans well forward, about the angle 60 degrees, and chin still further declined so that the oral axis is 45 degrees or less. This obviates the necessity in sinus work of the post-nasal plug, and in tonsillectomy of any swabbing or suction apparatus, and absolutely prevents blood inspiration when nitrous oxid-oxygen is administered.

Hemorrhage is reduced to a negligible factor by the dull dissection and finger enucleation, no sharp instruments being employed. The tonsil is simply peeled out of its capsule. It has been demonstrated that the tonsillar vessels very rarely bleed, but that profuse hemorrhages usually come from the severance of vessels in the surrounding muscles by sharp dissection or cutting through tonsil tissue. Postoperative hemorrhage is often induced by wretching and straining from ether or chloroform nausea and vomiting, which we avoid.

The danger of shock in any surgical operation is proportionate to the character and duration of the operation, and to the loss of blood.

This technic shortens the operative period to three minutes or less for the removal of both tonsils and adenoids; and sinus work is proportionately shortened and may be done thoroughly. This is due to the perfect view which the operator has in this position; his field clear of blood, without waiting for sponging, no time lost between anesthetic periods, as it is continuous, and both tonsils are removed at the same time by two sets of instruments.

The anesthetic is administered with equal facility in both nasal and oral operations, the process only being reversed. In some cases a partial nasal obstruction renders the oral administration easier than nasal.

In nasal and sinus surgery a special mouth inhaler is used, the gases being expired through the mouth; and in oral work both a small nasal inhaler and a mouth hook are simultaneously employed whereby the gases can be forced with sufficient rapidity to induce anesthesia, preventing the inhalation of air through the open mouth.

PURSUING THIS SAME subject W. H. Roberts, of Pasadena, Cal., addressing the American Laryngological, Rhinological and Otological Society emphasizes the fact that the position of the patient while being operated under ether, for the removal of diseased tonsils, is one that deserves serious consideration. As we constantly see and treat the throats of our patients while they are sitting upright, says Roberts, we naturally acquire a familiarity with the relationship of the various structures as thus presented to view, and we attain a manual dexterity in our treatments which a change in the patient's position necessarily lessens. It would seem that tonsillectomies could be more readily performed with the patient in the upright position than in any other, if the patient can be safely placed in the upright position when under ether.

TONSILLECTOMY IN THE UPRIGHT POSITION.

BEFORE ADOPTING THE UPRIGHT POSITION for tonsillectomies under ether, I carefully investigated the possible hazards of this position. I knew that for years it had been the custom of the nose and throat surgeons on the staff of the Massachusetts Charitable Eye and Ear Hospital to do all tonsil and adenoid operations under ether with the patients sitting up in a chair. While there, I had inquired for fatalities following these operations, and I learned they had had none. Personal communications from various friends of mine who had been connected with this hospital were to the effect that there never had been a fatality in Boston that could in any way be ascribed to the upright position.

For the last ten years I have done practically all my tonsillectomies after the manner about to be described, and I have yet to see any unfavorable condition either during or after the operation that could be attributed to the upright position. This position, in addition to the advantage of having the parts in the position in which we are the most familiar with them, offers several other advantages:

1. The ease with which the field of operation can be illuminated, either by an electric headlight, such as I use, or by natural or artificial light coming from behind and above the surgeon's head.

2. The ready accessibility of the parts to be operated on.

3. The freedom with which an assistant can hold instruments and can sponge the field of operation.

4. The simple control of the hemorrhage at its source, and the prevention of the entrance of blood into the larynx.

5. The thoroughness with which the operative field can be examined for tonsil remnants, tissue shreds and bleeding points after the enucleation.

6. The ease of control of the patient's head by the anesthetist.

The entrance of blood into the larynx during the operation is an objection raised by some to the upright position.

Dr. R. Bishop Canfield, of Ann Arbor, has examined the larynges of many patients operated in the prone, as well as in the upright, position. In a personal communication he says: "There seemed to be no more blood in the larynx after operations in the upright position than after operations in the recumbent position. In no case did the amount of blood amount to much, but appeared more like a stain or a small, thin clot. The vocal cords were streaked in some cases; in others, the posterior wall showed a little dry blood. * * * In my experience, there is much less blood in the mouth and pharynx during operation in the upright position than in the supine position. * * * I have never seen any accident that could be attributed to operation in the upright position. This statement covers several thousand cases."

The amount of blood gaining access to the larynx depends on the depth of the anesthesia. The patient should never be so deeply anesthetized as to be unable to swallow the blood and mucus that might collect at the entrance to the esophagus. It is obviously easier to swallow in the upright position than when lying prone. Further, the anesthesia should be so timed that the patient should be partially awake at the conclusion of the operation. As the anesthesia is so important a part of the operation, it necessarily follows that it should be administered only by an expert, and by the one who is accustomed to the surgeon's technic.

STAGES OF THE OPERATION.

THE INSTRUMENTS ARE ARRANGED in the order of their use on a table at the surgeon's right. The assistant stands at the surgeon's left, beside a table containing the sponge forceps which are loaded by a nurse as required.

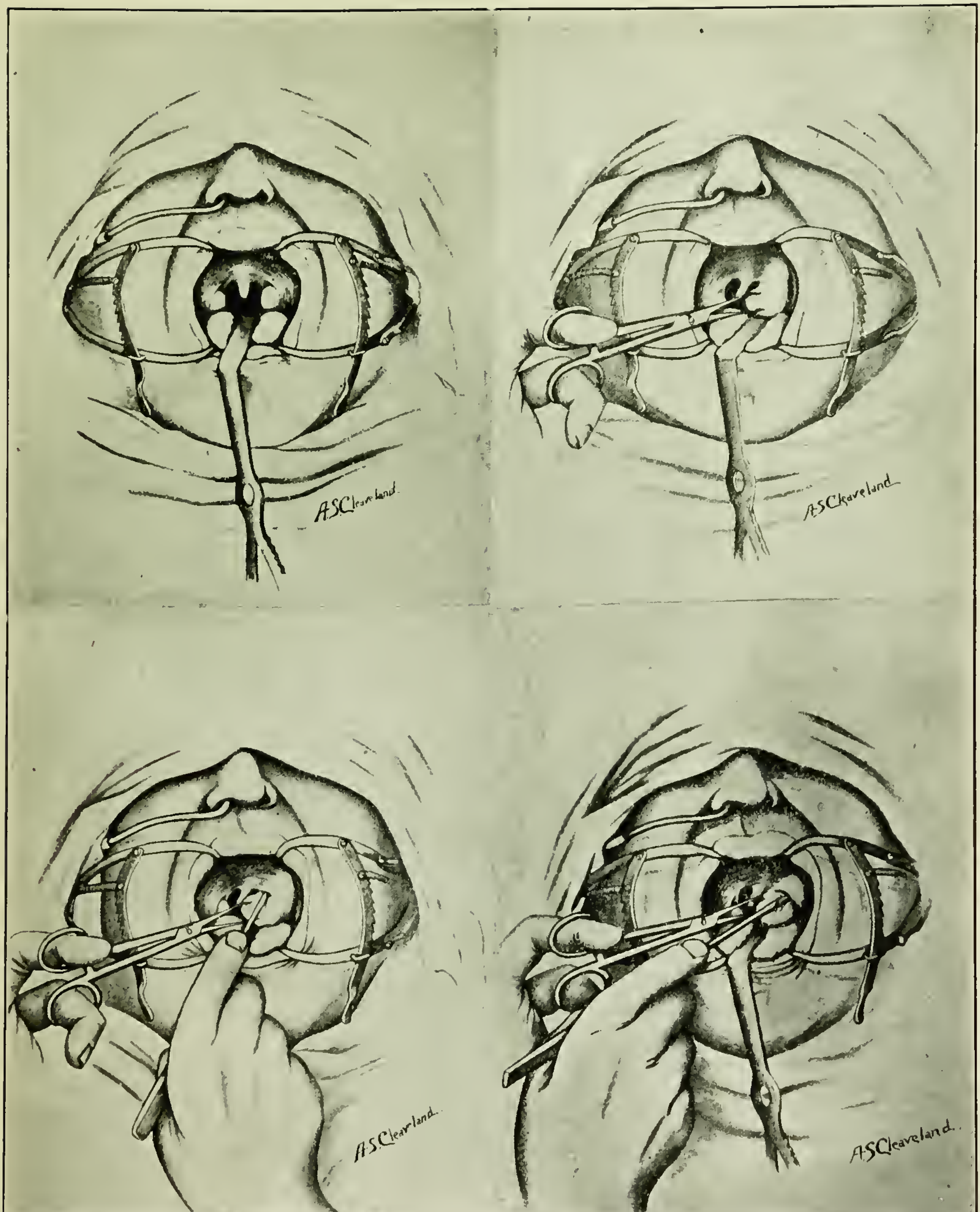

Fig. 1. Whitehead gag in position. Tongue controlled by a separate tongue depressor. Ether administered through a nasal tube.

Fig. 3. Knife blade entering one millimeter above the semi-lunar margin of the plica supra-tonsillaris, and keeping between the plica and the tonsil capsule.

Fig. 2. Traction being made on left tonsil, outlining the upper portion which is usually concealed in the supra-tonsillar fossæ.

Fig. 4. Freeing the anterior pillar with blunt pointed Tyding's knife.

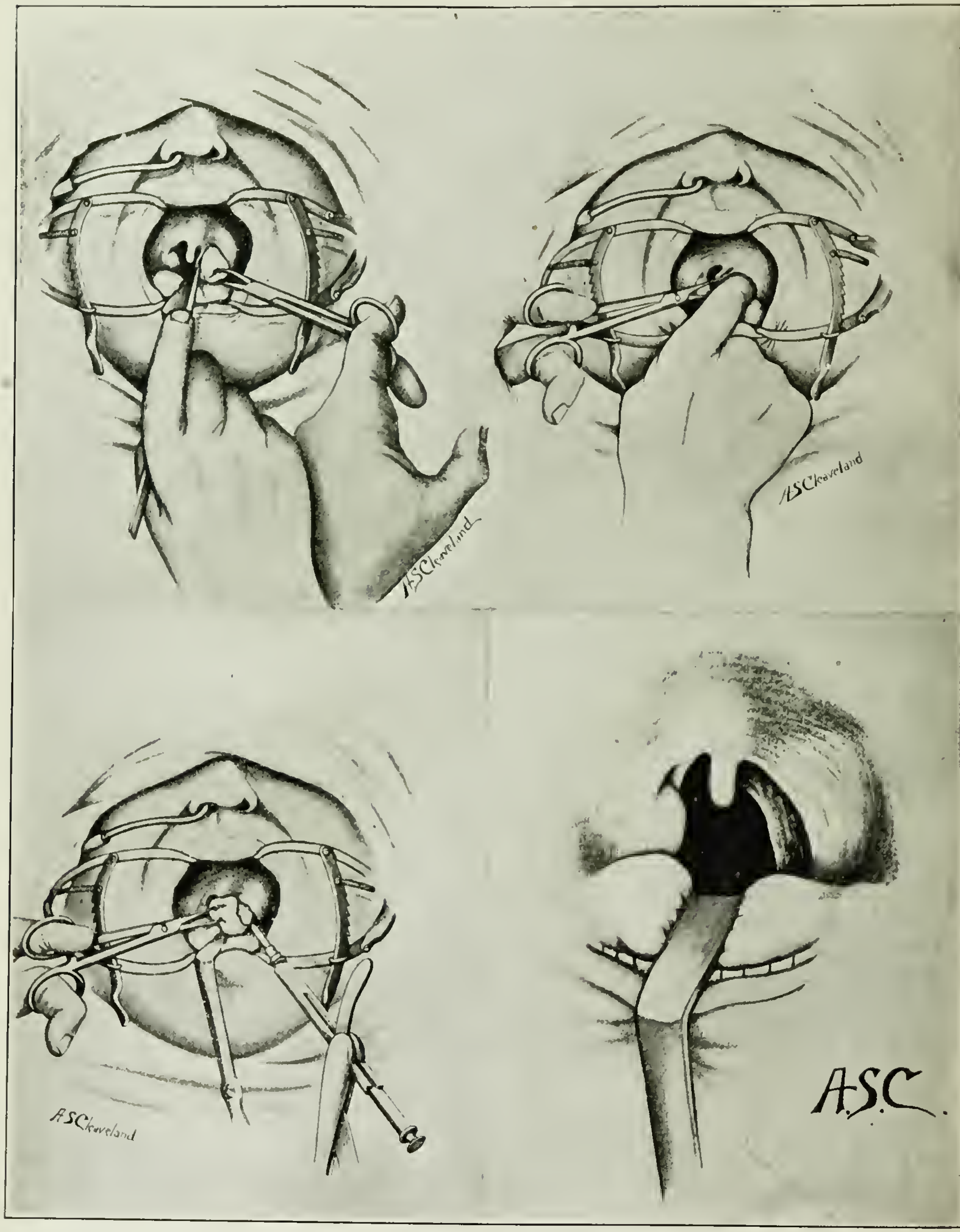

Fig. 5. Freeing the posterior pillar with blunt pointed Tyding's knife.

Fig. 7. Slipping the loop of a Tyding's snare over the dissected tonsil.

Fig. 6. With the index finger determine whether or not the tonsil is free in the supra-tonsillar fossæ and separated from the anterior and posterior pillars.

Fig. 8. The appearance of the pillars after removal of the left tonsil.

Another nurse acts as an assistant to the anesthetist.

The various stages of the operation are as follows:

1. The patient is anesthetized in the prone position, and, when thoroughly under the ether, is placed in a chair in front of the operator, who is so seated that his head is about on a level with that of the patient.

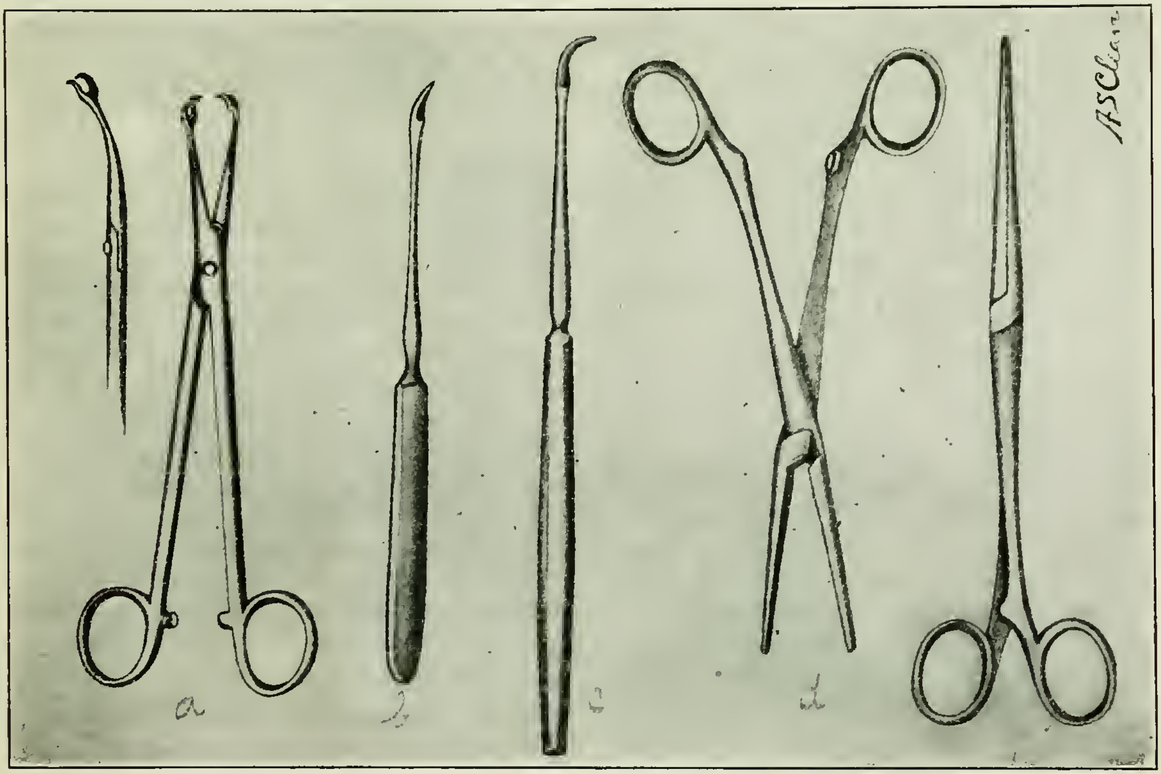

Fig. 9. a. Vulsellum forceps. b. Knife for primary incision. c. Tyding's blunt pointed knife. d. Combined sponge forceps and artery clamp.

2. The anesthetist then stands behind the patient, so as to control the head and to continue the administration of the ether through a tube introduced through the right nostril. A foot pump forces air through a bottel containing the ether, and the vapor is carried by a rubber tube to the patient's nose.

3. The patient is covered from the neck down with a sterile sheet that extends over the surgeon's lap; a Whitehead gag is inserted; and, after depressing the tongue, the parts are inspected and all mucus is wiped from the pharynx (Fig. 1).

4. The left tonsil is then firmly grasped by a vulsellum forcep (Fig. 9-a), and sufficient traction is made upon the tonsil to cause its concealed outlines fully to be revealed behind the pillars (Fig. 2). This is very important, as it at once shows the large portion of the tonsil occupying the supra-tonsillar fossæ.

5. While keeping traction on the tonsil with the vulsellum, a small incision is made one millimeter above the semi-lunar margin of the plica triangularies or plica supra-tonsillaris. This is done with the small bladed knife shown in Fig. 9-b. The knife blade should pass well up between the capsule covering the anterior portion of the velar, or supra-tonsillar lobe, and the plica supra-tonsillaris (Fig. 3). It is very important that this incision be not too deeply placed for fear of getting inside the capsule of the tonsil.

The secret of the success of any tonsil enucleation lies in keeping just outside the capsule of the tonsil and in keeping inside the tonsil fossæ. Fetterolf, in a recent article, deals with this point in a very thorough manner. (American Journal of the Medical Sciences, July, 1912, No. 1, Vol. cxiiv, page 37.)

6. A blunt pointed Tyding's knife (Fig. 9-e) is then used to free the tonsil margin from the mucous membrane layer of the plica triangularis, first along the anterior pillar (Fig. 4), and then along the posterior pillar (Fig. 5).

7. The tongue depressor should now be removed; tension should still be exerted on the tonsil, which is grasped by the vulsellum; the index finger of whichever hand is more convenient is passed over the top of the tonsil between the capsule and the supra-tonsillar fossæ (Fig. 6). If the finger meets with resistance, reintroduce the Tyding's knife and sever any bands which may prevent the finger entering the supra-tonsillar fossæ. Then gently sweep the finger down between the anterior pillar and the capsule, and between the posterior pillar and the capsule; pay particular attention, by digital dissection, to the freeing of the tonsil at its inferior portion near the tongue.

8. Having satisfied oneself by means of the finger that the dissection is finished and the tonsil free from any attachments in the supra-tonsillar fossæ or to either pillar, slip the loop of the Tyding's snare over the handle of the vulsellum which is still making traction on the tonsil, and carefully work the loop behind the tonsil (Fig. 7).

9. The field of operation should now be carefully sponged before tightening the wire, in order to satisfy oneself by inspection that the uvula and the pillars are not included in the loop. The loop is slowly tightened, and, when the tissues at the back of the tonsil capsule are cut by the wire, the tonsil is removed by the vulsellum.

10. Instantly the assistant introduces into the tonsil fossæ a gauze sponge on a sponge holder, making pressure till the bleeding stops. Should occasion require, these sponge holders can also be used as artery clamps to control any persistent bleeding (Fig. 9-d). I have never found it necessary to tie a vessel.

11. After checking the bleeding, the right tonsil is removed in the manner just described for the removal of the left tonsil.

The appearance of the pillars after the enucleation of the left tonsil is well shown in Fig. 8.

FOR MANY YEARS Frank Dyer Sanger, of Baltimore, Md., has also been operating on his patients under ether in the sitting posture. While this posture is used in the North there seems to have been a great deal of skepticism regarding its safety in the South. Sanger, therefore, endeavored, in a paper entitled "Some Advantages of the Sitting Posture in Nose and Throat Operations under Ether," which he read before the Eye, Ear, Nose and Throat Section of the Southern Medical Association, at Memphis, November 12, 1917, to show that many examples in clinical medicine suggest that the sitting posture possesses certain distinct advantages. More recently in addressing the American Association of Anesthetists, during the Seventh Annual Meeting at Atlantic City, June 9-10, 1919, Sanger said:

I would not presume to present before this body of experts any technical question connected with the administration of ether; what I shall venture to do is to call your attention to certain well established clinical observations regarding the behavior of individuals suffering from respiratory embarrassment, and inquire whether, since unconsciousness is not causatively related to the respiration but is an associated phenomenon, these observations do not justify a posture which might be termed the posture of selection from a respiratory standpoint in all operations which would not be hampered by it; whether these clinical observations could not be made helpful in the management of the respiratory difficulties which may arise in the course of anesthesia, and particularly, whether, in dealing with the more serious respiratory complications, with apnea, for instance, it would not be wiser to be guided by what the individual would probably do were he awake. In substituting our consciousness for the consciousness of our patient, should we not do for him what he would do for himself were he conscious?

RESPIRATORY PHENOMENA UNDER ETHER NARCOSIS.

DURING THE COURSE of ether narcosis, the respiratory phenomena are those which give us the most concern; one sees not infrequently some manifestations of suffocation, cyanosis, dyspnea, occasionally apnea. The clinician sees the same phenomena, and is impressed by the fact that under practically all circumstances the individual, when respiration is embarrassed, irrespective of the cause of the embarrassment, instinctively and sometimes unconsciously, assumes such a position as will insure the greatest freedom of respiratory movement. I trust that I may be permitted to quote at length from the paper above referred to.

REACTION OF THE CONSCIOUS PATIENT TO RESPIRATORY EMBARRASSMENT.

UNLESS PAIN IS A dominant consideration, the patient suffering dyspnea from compression of the lung, due to processes involving the pleura, always assumes a position which will insure the freest possible movement of the unembarrassed lung. Instinctively the individual with consolidation in one lung lies upon the side affected, to afford greater freedom of movement to the unaffected side. A disassociation of movement is thus accomplished in pathological conditions which would be physiologically impossible.

"When dyspnea results from bilateral conditions in the lung, from disturbances in the respiratory tract down to the division of the trachea, from conditions affecting the musculature of respiration, or the innervation of these muscles, the patient seeks an upright position. The person whose breathing is temporarily obstructed as a result of a simple coryza, finds it more comfortable to sleep high; the individual at table who chokes, instinctively gets up; the child suffering from laryngeal obstruction insists upon being held, and with broncho-pneumonia finds relief in an upright position upon the mother's shoulder. Spasm of the respiratory muscles, like spasm of the larynx, brings the individual almost instantly into an upright position.

"Even more striking is the position assumed by patients suffering from circulatory disturbances in the lungs. One recognizes one's cases of broken compensation at a glance as one passes through the general ward by the upright position assumed by the patients in bed. Their ability to sleep at a lower angle from night to night bespeaks the restoration of the circulation in the lungs, as certainly as does the fading of the cyanosis. Few pictures are more impressed in their uniformity in all clinical medicine.

"One might go on citing instances to substantiate the general proposition that dyspnea, which is the first phase of asphyxia, and which may eventuate in apnea if carried to its logical conclusion, determines decubitus when caused by unilateral conditions, and, when due to bilateral causes, brings the individual into a vertical position to insure greater freedom of all the usual respiratory mechanism and to call into activity all the so-called accessory muscles of respiration, which seem to be used to greater advantage in the upright position.

"Participating in this emergency work are the following muscles—the scaleni, trapezius, levator-anguli-scapulæ, sterno-cleido-mastoid, the sterno-thyroid, sterno-hyoid, serrati and pectorals. The last five probably aid inspiration by temporarily reversing their fixed point.

"Another possible reason for assuming the upright position is to relieve the diaphragm of the embarrassment of pressure, particularly when the abdomen contains fluid. It is also possible that gravity influences materially the venous congestion of the brain and relieves the respiratory center. In the absence of a state of almost complete annulment of the circulation in the arteries, it does not seem to me that gravity could greatly influence arterial flow.

"While these phenomena may be subject to slight variations in individual cases, I think it is true that a conscious person suffering any degree of asphyxia from any cause never voluntarily assumes a position which would hamper his respiratory movements, and he, particularly, would not dream of lowering his head below the horizontal. The asthmatic gentleman finds great satisfaction in so small a matter as an unbuttoned waistcoat. The orthopneic sufferer, in his extremity fighting for air, although suffering the most extreme exhaustion, sits upright in a straight arm chair, firmly grasping the arms in his efforts to maintain a fixity of position, that will insure the greatest possible action of every available muscle of respiration."

THE ANESTHETIST'S TRADITIONAL MANAGEMENT OF RESPIRATORY EMBARRASSMENT.

THESE FEW EXAMPLES are sufficient to show that conscious individuals react to respiratory embarrassment along definite lines; when, however, the individual is unconscious, and respiratory embarrassment supervenes, as may occur in the course of anesthesia, the anesthetist substituting his consciousness for that of the patient, is apt to move along traditional lines which have come to be accepted operating room procedure; the jaw is carried forward, the tongue is grasped with forceps and dragged out of the mouth, the head is lowered from the end of the table, sometimes the lower portion of the body is raised. The next usual step is some form of artificial respiration.

"Carrying the jaw forward is undoubtedly a good practice if at the same time the mouth is opened; but pushing the jaw forward, at the same time jamming the mouth shut, increases the difficulty or renders breathing impossible in persons who are not free nose breathers, or in those cases—which are frequent—in which the venous congestion has so overfilled the turbinal bodies that the nose is occluded in consequence. Dragging the tongue out of the mouth is also beneficial in its results, but does violence to that organ, causing in some instances great after-discomfort, and subjects the patient to the danger of infection through laceration.

"It is gravity that causes the tongue to go back and obstruct breathing. The same gravity will cause it to go forward and open the glottis if the patient is put in a suitable position. It is doubtful whether dragging the tongue forward has any other influence upon spasm of the glottis than to increase it, although intermittent traction of the tongue is probably a stimulant to inspiration. Dropping the head from the end of the table and raising the lower half or two-thirds of the body, using in either case the shoulders for a fulcrum, places all the posterior accessory muscles of respiration at the greatest possible disadvantages, since they are bearing the weight of the body. The extreme extension of the head stretches the anterior group to such an extent that their action is also impaired. The inversion of the patient brings the weight of the abdominal contents upon the diaphragm, rendering its contraction more difficult, and finally gravitation dams back into the brain upon the respiratory center the blood surcharged with carbon dioxid. (Ask the next cyanotic individual you meet to stand upon his head and see if any consideration you can name will induce him to do it.) Fortunately these errors are usually committed serially; were they all accomplished at the same moment of apnea the recuperative powers of the patient would less frequently prove equal to the situation."

ARTIFICIAL RESPIRATION.

THE NECESSITY FOR artificial respiration will less frequently arise if everything is done to enable the patient to utilize his own powers. When we substitute artificial respiration for the natural function which we have helped to abrogate by hampering the respiratory mechanisms, the responsibility for the failure must rest upon us.

If artificial respiration becomes necessary it is of most vital importance that the entire respiratory mechanism be cleared for action, so to speak; our effort in performing artificial respiration is but the expression of the hope that the muscles will resume their action. We diminish that hope and frustrate our effort by placing the slightest obstacle in the way of natural respiratory movement, which clinical experience has abundantly shown to be best in the upright position.

One does not, in attempting to start a delicately adjusted mechanism, first throw that mechanism out of adjustment or place some obstruction in gears or bearings; similarly, in trying to re-start the respiratory mechanism, every muscle should be so unhampered that it will be able to respond to the faintest stimulus that may reach it. Recumbency does not meet these requirements. Its continued employment seems to me to be largely a matter of tradition.

It is probable that the recumbent position has been associated with the unconscious state from the earliest time. Sleeping recumbently no doubt gave rise to this association. It antedates all physiology. The fainting person must be placed in the horizontal position else he will fall.

THE THEORY OF ANEMIA OF THE BRAIN.

I AM UNABLE TO SAY when the theory of anemia of the brain was first propounded, but it probably long antedates experimental physiology. It had become axiomatic in the profession when the use of anesthetics began. What could be more natural than that it should have become a guiding principle in anesthesia; that operating room tradition should be based upon it? Yet, what do we mean when we say anemia of the brain? Is there any clinical evidence to show that the difference between the amount of arterial blood in the respiratory center in the recumbent position and the upright position is sufficient to influence respiration? What is the laboratory evidence upon this question? Is the question not a qualitative rather than a quantitative one? A question of the blood content? The carbon dioxid content?

One is constantly confronted by the anemia of the brain theory when one discusses the untoward occurrences under ether anesthesia. So far as I have been able to discover there is no other reason for recumbency. No one seems to be willing to question their faith in the anemia of the brain theory, hoping no doubt, that they will not have an anesthetic casualty, and expecting their faith to sustain them in case the casualty occurs. On the other hand, the advantages of the upright posture in all cases of respiratory embarrassment are matters of such common experience that it seems strange that we have not availed ourselves of these advantages in other emergencies.

THE COMMON OBJECT OF ARTIFICIAL RESPIRATION.

THE VARIOUS METHODS of artificial respiration have for their common object the rhythmic expansion and contraction of the chest, resembling as nearly as possible the natural movements of respiration. The movement of the ribs is accomplished by the external application of force in the absence of muscular contraction. The method at present most in vogue is to place the body in the prone position in order to permit the tongue to fall forward, opening the glottis; at the same time to relieve the diaphragm of pressure. In this posture, however, the trunk is weighing upon, and hampering the movement of some of the most important respiratory muscles, it is a weight that must be lifted by each expansion of the chest. The force is then applied to the postero-lateral aspects of the thorax; in other words, nearer to the articulated than to the free ends of the ribs; in the upright position with the head flexed the tongue gravitates forward and the glottis is open. Freedom from pressure upon the diaphragm is much more assured in the upright than in the prone position, the trunk not being added to the muscle load. In this position an operator and his assistant, without a great amount of exertion can perform artificial respiration as long as there is reasonable hope of restoring the patient, being able to relieve each other without changing their positions, therefore without interfering with the rhythm of the respiratory movements; for while the assistant holds the head from behind (assuming that the patient is seated in a chair) maintaining the patient in the perpendicular, and, at the same time seeing that the head is flexed and if necessary the jaw forward, the operator seated in front of the patient is able to apply force to the antero-lateral aspects of the thorax nearer the free than the articulated ends of the ribs, which gives the same obvious advantage which would result from trying to manipulate a door or other hinged object from a point distal rather than proximal to the hinge. The operator, to relieve himself of the fatigue of such a procedure carried on for some time, can easily maintain the position of the patient from the front, keeping the head flexed, while the assistant, relieved of that duty, by encircling the patient's thorax in the attitude of embrace, will be able to continue the rhythmic movements of the chest at as great a mechanical advantage as the operator in front; and here, too, the force is applied to the more movable portion of the thorax rather than to a point of relatively little movement, *i. e.*, the postero-lateral aspect. When a chair is not available, as for instance in drowning cases, when artificial respiration must be performed on the ground, the operator and assistant can kneel or sit in comparative comfort; otherwise proceeding as described above.

During the performance of artificial respiration by this method the patient is at all times in the best possible position to respond to any efforts that may be made by the muscles to resume respiratory movements.

ROLE OF THE HEART.

IT MAY BE OBJECTED that I have not taken the heart into consideration in this discussion. I have not done so because it does not seem to me that the phenomena ordinarily observed in the course of ether administration are heart phenomena at all. Were I convinced that the phenomena were wholly due to failure of the heart I might adopt a different procedure. Or if, in the presence of both heart and respiratory manifestations, it seemed as though the respiratory phenomena were secondary to the heart failure, I doubt, even then, the advisability of adopting a procedure which no degree of hardihood would induce one to undertake were the patient conscious. Does any one think of forcing his conscious patient, gasping for breath on account of failing heart, to lie down? Would he ever under any circumstances invert his patient? Not only does the upright position seem safe to me, but experience has taught me that it is comfortable for the patient, the after discomforts, such as ether-back, ether-tongue, etherjaw not being experienced.

ADVANTAGES OF THE UPRIGHT POSTURE.

THE POSITION OFFERS numerous advantages from the operator's standpoint; the exposure is good, illumination is easy, hemorrhage, particularly venous oozing, is less troublesome than in the recumbent position; therefore less assistance is required, which is an important consideration when operating in so small a field as the nose and throat. Ether administration by any method in this position is easy; not infrequently the anesthetizer with whom I am accustomed to work, finds it convenient to hold the head during short operations, as for instance tonsillectomy and adenoidectomy, thus simplifying the procedure.

Never having had an ether death or a serious ether emergency in a period of twenty-two years, during which I have employed the upright position constantly, it is but natural that I feel like urging its more general use.

THE NASAL ADMINISTRATION OF NITROUS OXID-OXYGEN ANESTHESIA UNDER LOW PRESSURE . DANGERS OF ADMINISTERING NITROUS OXID ALONE . ADVANTAGES OF ADMINISTERING NITROUS OXID WITH OXYGEN . APPARATUS FOR THIS PURPOSE . REGULAR FLOW OF GASES . VISIBLE CONTROL . METHOD OF ADDING ETHER . AIR-TIGHT NASAL PIECE . HANDLING EMERGENCIES . ADVANTAGES OF LOW PRESSURE ANESTHESIA . DESCRIPTION OF THE NEW NASAL INHALER . POINTERS IN LOW PRESSURE ADMINISTRATION.

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THE OPINION that nasal anesthesia with the mouth open requires high pressure and with it large volumes of gas and oxygen was questioned by M. Ecker, of New York City, in speaking before the New York Society of Anesthetists, at the meeting of May 2, 1917. Ecker contends that better anesthesia is procurable under low pressure administration and he believes that low pressure may be found to be the clue to the solution of the technical problem of giving nitrous oxid-oxygen for oral surgery. Ecker elaborated his views before the Fourth Annual Meeting of the Interstate Association of Anesthetists, in Toledo, O., and illustrated his point of technic with moving picture demonstrations.

It is not the purpose of this paper, says Ecker, to trace the history of nitrous oxid as an anesthetic agent, nor to dwell upon the various theories concerning its action, as deduced from experimentation with lower animals. The parts played, in directing attention to this new use of *laughing gas*, by Dr. Colton, who, in 1867, reported 20,000 administrations of nitrous oxid, and by Dr. Wells, who foresaw the possibilities of this agent, are now matters of common knowledge.

It may be brought to mind, however, that these two pioneers employed nitrous oxid alone, thus inducing an asphyxial form of anesthesia. Dr. Andrews, in 1868, was one of the first to report the use of nitrous oxid in combination with oxygen, thus obtaining a non-asphyxial, and consequently a safer and more satisfactory form of anesthesia. With the addition of ether this form of anesthesia is now used in over 80 per cent. of all surgical operations, whereas nitrous oxid and oxygen is considered the ideal anesthetic in minor surgery.

DANGERS OF ADMINISTERING NITROUS OXID ALONE.

ACCORDING TO GWATHMEY, experimental observations have established the fact that nitrous oxid, when given alone, induces asphyxia by the gradual paralysis of the respiratory center. In consequence of the prolonged action of the increasingly deoxygenated or venous blood, the respirations, at first rapid and deep, become convulsive as the process of deoxygenation is continued, then slow and shallow, finally ceasing altogether. Nitrous oxid, therefore, causes death by asphyxia.

With an increasing knowledge of the physiological action of the gas and with a clearer understanding of the dangers involved, the use of nitrous oxid alone has been practically abandoned. It is now generally employed in combination with air or oxygen.

ADVANTAGES OF ADMINISTERING NITROUS OXID WITH OXYGEN.

IT HAS BEEN FOUND from experience, re-enforced by animal experimentation that certain advantages are derived from the administration of nitrous oxid with oxygen. These are:

(1) The anesthesia is non-asphyxial, safer, deeper, and more satisfactory in every way than when nitrous oxid is given alone.

(2) The anesthesia can be maintained for an indefinite period of time, without danger to the patient, and without embarrassment to the operator, especially when a nasal inhaler is properly employed.

APPARATUS FOR ADMINISTERING NITROUS OXID WITH OXYGEN.

FOR SHORT ORAL OPERATIONS, such as the extraction of a single tooth, or the opening of an abscess, the face mask has its place; but for longer operations such as the extraction of a number of teeth, or the handling of the various anomalies which the dental surgeon encounters, a nasal inhaler is now considered an absolute necessity. Considerable thought, therefore, has been devoted to the matter of devising an apparatus which meets all the requirements, not only with regard to the inhaler *per se,* but as to the apparatus as a whole. What are these re-

Fig. 1. Placing the rubber ball of the Ecker Nasal Inhaler in position by adapting it to the bridge of the nose, then pressing it gently downward.

Fig. 2. Metal cover and breathing bag adapted to the rubber ball and strapped in position.

quirements?

(1) There must be an absolutely regular flow of each gas, at any rate desired, without the necessity of frequent valve or stop-cock manipulation.

(2) The flow of gases must be rendered visible, so that these proportions may be approximately estimated at a glance.

First: *Regular Flow of Gases.* The percentage of oxygen need give the operator no concern. The patient is the guide. The proportion of oxygen has been estimated at anywhere from 5 to 10 per cent. Conditions must govern the increase or decrease of the gases. Once the rate of each is determined, the regular flow must be maintained. This is the crucial point.

Fig. 3. Side view of the inhaler in position.

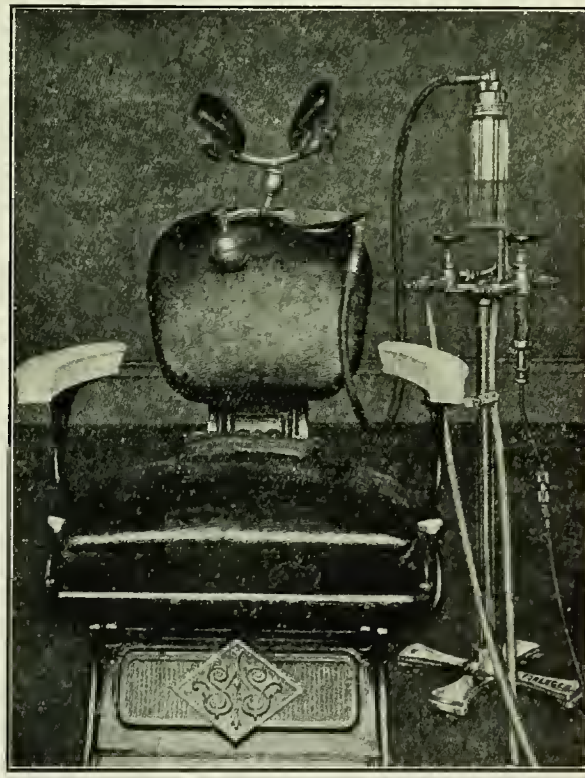

Fig. 4. Author's arrangement of apparatus and sight feed adapted for dental anesthesia and analgesia.

(3) An efficient method must be available for adding ether vapor gradually, yet rapidly, up to any amount that even an extreme case may require.

(4) The nasal piece must be so modified as to be absolutely air-tight, and also practically self-retaining. Let us consider for a moment, each of these requirements.

To obtain an even flow of nitrous oxid and oxygen from the liquid form, where the larger cylinders, that is, those containing 1,280 gallons of nitrous oxid and 400 gallons of oxygen are used, automatic reducing valves are necessary. For general use, however, cylinders containing 250 gallons of nitrous oxid and 75 gallons of oxygen are more practical. These are attached directly to the apparatus, not requiring reducing valves.

Second: *Visible Control.* The apparatus must be so constructed as to render the rate of flow or percentage of the gases visible, so that the relative proportion of each gas may be estimated at a glance. This assures the operator that the flow is actually taking place. This has been solved by having each gas bubble pass separately through equal parts of glycerin and water, into a glass mixing chamber. The volume of gases delivered to the patient is controlled by a fine needle-valve adjustment, acting against the low pressure delivered by the reducing valve. The important factor is to determine the proportion of nitrous oxid and oxygen suitable to the individual patient. Practice is the only sure teacher and guide, but after several administrations, and by close observation, by being able to recognize the various symptoms, and by paying attention to the proper adjustment of the nasal inhaler, the valves can be so regulated as to maintain normally *pink* anesthesia.

Third: *Method of Adding Ether.* The ether attachment for our routine is seldom used. In extreme cases I occasionally give a little ether with the nitrous oxid and oxygen.

Fourth: *Air-tight Nasal Piece.* Some years ago Dr. Teter improved the technic of nasal anesthesia when he devised a method of using oxygen with warm nitrous oxid by means of his nasal inhaler. I have never seen a metallic or a rubber inhaler that could be considered universal, that is, one that could be adapted to fit any nose without a slight leakage of air, thereby failing to give a perfect anesthesia. I tried one of these metallic inhalers with an aperture and an extended rim, so that gauze could be packed in to fill out the various anatomical structures, thus fitting the various size noses with which I was confronted. I came to the conclusions that for perfect adaptation a nasal inhaler must be constructed of soft rubber. I therefore proceeded to devise the one which I am presenting herewith. It is absolutely air-tight, it is self-retaining, it can be used for an indefinite period, it can be boiled and sterilized, it costs very little, and it can readily be replaced.

I may call to mind, in this connection, the objectionable features of the exclusive use of the face-mask. They are apparent to all. The middle or index finger of the right hand must be held over the controlling valve, and the left hand over the nose and mouth of the patient to insure perfect adaptation. Very often, during anesthesia, the patient displaces the mouth-prop, rigidity sets in, and you have to wait until the anesthesia becomes shallow before you are able to force the jaws apart and to replace the prop. Now you either extract one or more teeth, or you again apply the inhaler and proceed to reanesthetize the patient. During the operation the mouth becomes filled with congested blood, the field of operation is obstructed, the patient becomes cyanotic; you endeavor to swab out the blood and saliva, and you try to remove the remaining teeth in a very short period of time. You invariably lacerate and do other uncalled-for injuries to the gums or other structures. No other thought enters the mind but to *get out the teeth.*

With nasal anesthesia, on the other hand, the inhaler being self-retained, both hands are free, you watch your patient, you see the prop, you can pack the throat with gauze, you can take your time; you can extract one tooth or more, and you can swab out the mouth or the sockets if necessary.

HANDLING EMERGENCIES.

NOW LET US ASSUME, that the respirations become shallow, the patient breathing through the mouth, or worse, holding his breath. This is a very important factor. In such event, stop the anesthesia, or lift the inhaler from the nose, for with the next inhalation the great pressure may cause muscular spasm, respiratory failure, and often serious results. If the patient struggles, or holds his breath, and then inspires deeply, the extra amount of gas brought to the heart suddenly may paralyze it. The danger of such an accumulation of gas at a time when it is not wanted, or when it would be risky for the patient, is practically impossible, with outfit presented.

Granting that the dentist who administers a general anesthetic, is able to recognize the symptoms of respiratory and cardiac failure; admitting that the best results are obtained when he is able to work with comfort and leisure, which means that he need not worry about the patient getting too much of the anesthetic or coming out of the anesthetic state before the work is done—what apparatus or combinations thereof, best meet these requirements?

It is my opinion that one of the principal reasons for my success is the low pressure with which the Gwathmey apparatus and my nasal inhaler permit me to work.

ADVANTAGES OF LOW PRESSURE ANESTHESIA.

THE OPINION THAT NASAL ANESTHESIA with the mouth open requires high pressure, and with it large volumes of gas and oxygen, is quite prevalent. But I can say that I am doing under low pressure, and consequently with small amounts of gas, just as well, even better than I formerly did with high pressure. I believe that in this difference between the two methods may be found the clue to the solution of the technical problem, that is, a proof that it is not essential or right to use high pressure for nasal anesthesia.

From a series of tests with a mercury gauge attached on the gas outlet of the sight feed, that is, directly in the gas channel to the patient, the pressure used did not exceed 10 millimeters, and was, on the average, below 5 millimeters. I can furthermore state that the amount of gas used is 2 to 4 gallons per minute. This is easily determined, since sight feed holes are of standard gauge, and the amounts passing through each hole are steady, without fluctuations, if the gas valve is heated. I now average about 5 to 7 gallons of nitrous oxid to an administration. Formerly, with high pressure, I averaged 10 to 12 gallons of nitrous oxid to an administration.

Why is it that I succeed, with *small amounts of gases under low pressure,* rarely with forcing, in obtaining a perfect nasal anesthesia? And when I say perfect, I mean an anesthesia which enables me to extract, with the greatest ease, and without fear that the patient will come out too soon, a mouth full of teeth, if this is necessary. My answer is that, in working *without leak and with a minimum loss,* through the mouth, by using low pressure, I am giving the patient no more than he can take. In short, as I have said before, with my nasal inhaler the danger of accumulation of gas at a time when it is not wanted, and when it would be risky for the patient, is practically impossible.

DESCRIPTION OF THE ECKER NASAL INHALER.

THE ECKER NASAL INHALER consists of a spherical rubber piece, a round cap metal holder with hooks for attachment of straps; an angular or straight nose nipple, with an expiratory valve; a small breathing bag, and rubber tubing leading to the apparatus.

It is as simple and compact as possible, and offers, with its rounded symmetrical surface, absolutely no obstruction to the operator's hand.

In conjunction with an apparatus delivering the gases at low pressures this inhaler consumes extraordinary small quantities of the anesthetic and produces results.

From the foregoing description you will now understand that in order to prevent the accumulation of gas when the patient stops breathing, and, conversely, to prevent the onrush of too large a volume of the mixture when the patient starts to breathe, it is not necessary to remove the inhaler. The accumulation of gas in the small rubber tube amounts to nothing, and the contents of the little breathing bag can be pressed out with one hand in one motion when the expiratory valve is open. If the occasion arises, I can shut off the gas-control valve, press out the mixture from the bag, and eventually let the oxygen run. A fresh supply of the mixture, whenever the time comes, is immediately obtained, eventually in different proportion with less nitrous oxid and more oxygen.

POINTERS IN ADMINISTRATION.

THE SMALLER THE AMOUNTS of gas and oxygen that you have to control, the better. Emptying the bag, refilling under different proportions, and setting a new mixture, is accomplished with this apparatus as quickly as it is spoken. The control is perfect.

I often get the patient under with gas only, or with a very small addition of oxygen. Whether I use gas through the fourth or fifth hole, or through the bottom of the tube, I will know immediately when watching the depth of the patient's rebreathing, as indicated by the small breathing bag. If I start with the fourth hole, and find that the patient empties the breathing bag, I go over to the fifth hole or to the bottom. *The rule should be that the breathing bag at the patient's expiration is nearly, but not quite, distended.* If the fourth hole keeps the bag nearly extended and the patient breathes normally, there is no reason to increase. On the other hand, if distention is full, and if the patient is a nose breather, it may be good to decrease the gas flow to the third hole, whereby again you should consider that by such rebreathing there will be no carbon dioxid, consequently the patient will stand more oxygen without the risk of coming to.

The small breathing bag attached close to the nasal inhaler is a wonderful indicator of the patient's breathing. If you are able to draw conclusions from the character of the breathing you will be able to utilize the rhythmic motions of the breathing bag as a guide for quickly obtaining and easily maintaining the proportions of the anesthetic mixture. I wish again to emphasize that this breathing bag and the visible gas flow through the sight feed place you in a position to master the situation from beginning to end.

In conclusion I desire to draw especial attention to the following points, observance of which will enable you to obtain a better and a safer anesthesia:

(1) Do not forget to use the rebreathing bag occasionally, for the rebreathing of the expired carbon dioxid acts as a respiratory stimulant.

(2) Do not cause much, if any, cyanosis in inducing anesthesia.

(3) Do not be in too great a hurry in bringing the patient under the influence of the anesthetic. Take your time, thus giving the system an opportunity to accustom itself to the anesthetic agents.

THE AGE OF ROMANCE STILL LIVES. AS LONG AS THE HEART OF MAN BEATS IN HIS BREAST IT CANNOT DIE. FOR ROMANCE IS NOTHING ELSE THAN LIFE IN ITS HIGHEST MOOD OF IMAGINATION AND IDEALISM, OF COURAGE AND ACCOMPLISHMENT, OF UNDERSTANDING AND ACHIEVEMENT. THIS IS AS TRUE TODAY AS IT WAS A THOUSAND YEARS AGO; AS TRUE OF AMERICA IN ITS ERA OF INDUSTRY AS IT WAS OF EUROPE IN THE ERA OF CHIVALRY. LIFE STILL HOLDS ALOFT THE TORCH OF ROMANCE TO FIRE THE SPIRIT OF MAN, TO KINDLE HIS AMBITION, TO IGNITE THE CREATIVE IMPULSE OF HIS ENERGIES. YET THERE IS A DIFFERENCE BETWEEN ROMANCE TODAY AND A THOUSAND YEARS AGO. IT BECKONS MEN LESS OFTEN DOWN THE PATH OF SHEER ADVENTURE; IT LEADS THEM MORE OFTEN UP THE HEIGHTS OF CONSTRUCTIVE SERVICE TO THE WORLD. IT CALLS MEN TO SCIENCE, TO INVENTION, TO INDUSTRY AND TO INTELLECTUAL AND MORAL LEADERSHIP.

—N. W. Ayer.

THE OPEN METHOD OF ETHERIZATION . FATALITIES DURING ANESTHESIA . ETHER-OIL COLONIC ANESTHESIA . INTRAVENOUS ANESTHESIA . OPEN ETHER . TECHNIC OF OPEN ETHER . ADVANTAGES OF OPEN ETHER . FALL IN TEMPERATURE . WARMED ETHER VAPOR . PRESERVATION OF BODY HEAT DURING ANESTHESIA . CONCLUSIONS FROM OBSERVATIONS .

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THE MOST HELPFUL aids to the advancement of our work as anesthetists are the critical analysis of errors and the investigation and discussion of the reasons for postoperative complications and fatalities during narcosis. Discussing this subject before the Joint Meeting of the Interstate Association of Anesthetists and the Mississippi Valley Medical Association, at Toledo, O., October 9-11, 1917, Isabella C. Herb, of Chicago, Illinois, by way of introduction to her Chairmen's Address on the "Open Method of Etherization" contended:

That anesthetic accidents during and following narcosis are in a large measure avoidable cannot be gainsaid. Many are due to lack of training, carelessness or to over-confidence in the safety of the agent being administered. The last group agree with Shakespeare in feeling that there is "No danger in what show of death it makes." However, those who are not observant or attentive to detail, although properly trained, will never make first class anesthetists either from the viewpoint of the patient's welfare or the surgeon's comfort.

Complications during anesthesia may be classified under two heads, (1) improper selection of the anesthetic agent and (2) faulty administration. It is not always easy to determine the proper share of blame which should be attributed to the surgical procedures in the postoperative complications, but this does not hold true in case of death during operation. Fatalities during anesthesia, when the patients are not moribund on entering the operating room, are due to improper selection or administration of the anesthetic, to a central respiratory or cardio-vascular paralysis produced by a toxic dose of the anesthetic agent or agents (combined anesthesia) to cerebral hemorrhage in patients suffering from sclerotic arteries with high blood pressure, or accidental hemorrhage during the operation. Death due to operative procedures other than hemorrhage occurs after the patient is returned to bed.

Fleming,[1] in a review of inquests held in England, shows that out of 700 deaths occurring during anesthesia, 521 were due to the anesthetic. Of these patients 223 died before the operation was begun. His statistics are interesting and instructive.

Chloroform	378
Ether	28
C. E., A. C. E., and A. C.	100
Nitrous oxid	12
Ethyl chlorid	6
Spinal	8
Scopolamin	2
Hedonal	2
Local	6
Not specified	158

In analyzing these figures one is at once impressed by the dominance of fatalities under chloroform and it is difficult not to attribute them to the improper selection of the anesthetic agent, although the inexperience of the administrators may have been a contributing factor. Fleming

1. FLEMING: Proc. Roy. Soc. Med., 1914, Vol. vii, 17.

is undoubtedly correct in his belief that this appalling death rate would not have occurred if ether had been administered instead of chloroform. From a purely scientific point of view these statistics serve to show the great need of reform in the selection and administration of anesthetics.

Too much credit cannot be given to the laboratory workers, that army of men and women who study for weeks or months on a single problem to prove or disprove a theory, to erase or put on a firmer foundation practices in medicine or surgery. Few, if any, representative surgeons or internists would be willing today to attempt a diagnosis, much less to institute a line of treatment, without the aid from the pathological, bacteriological and X-ray laboratories. The work of these medical allies cannot be ignored by the anesthetist if he would advance the science of anesthesia. However, it must not be forgotten that laboratory workers lack clinical experience and therefore their deductions are not always reliable. For example, to ascertain the real facts and expose the utter fallacy of recent published statements[2] with reference to the open method of etherization there is necessary only a very little clinical experience, a very little observation unbiased and unprejudiced to prove that the picture described is so foreign to the actual condition of the patient that it is impossible to harmonize the two. However, it is quite incomprehensible how ether can act so differently when given by two people using the same method of administration and the same brand of ether. Is it the gun or the man behind it which controls the situation?

Let us for a moment consider the introduction of ether into the body by other channels than the respiratory system.

ETHER-OIL COLONIC ANESTHESIA.

THE ETHER-OIL COLONIC technic of Gwathmey has many advantages over the ether-vapor rectal anesthesia. Upon superficial observation the method is so simple that it has attracted the unwary. Upon close inspection, however, it is at once evident that it has not only distinct limitations but also distinct disadvantages. Adults are given one ounce of a 70 per cent. solution (6 oz. of ether and 2 oz. of olive oil) for every twenty pounds of body weight; that is, a man weighing 140 pounds would be given seven ounces. Children are given a 50 per cent. solution. The personal equation enters so largely in drug susceptibility that it would appear hazardous to attempt to figure the dosage on the basis of body weight and age. Not to have the anesthetic under immediate control in case of untoward accident, as for example in sudden severe hemorrhage, is a distinct disadvantage which the merest tyro will recognize. We are told that if at any time the patient shows signs of a too profound anesthesia a portion of the mixture should be withdrawn. While this is itself is a simple procedure the disorder occasioned by such a necessity during a major operation must be considered. What assurance have we that the injected solution will remain in the rectum, especially if the operative requirements place the patient in the Trendelenburg position? Is it not possible that the solution had already passed into the colon and cecum in the reported cases of respiratory depression. If such is true the futility of an effort to quickly recover it through lavage is evident. Inasmuch as the ether is excreted by the lungs, if respiratory depression develops less ether is eliminated, while at the same time it continues to be absorbed from the rectal solution which in turn still further depresses respiration. Another objection to the method is the inability to regulate the depth of narcosis to suit the operative requirements during the different stages of the operation.

Reports[3] indicate that occasionally rectal irritation which may prove quite distressing, or end in death, follow this method of etherization.

INTRAVENOUS ANESTHESIA.

ETHER IS SOLUBLE IN NORMAL SALT solution to the extent of 10.8 per cent. by volume. At first a 10 per cent. solution was in-

2. Bryant, John and Henderson, Yandell: The Journal A. M. A., 1915, Vol. lxv, 1.

3. Montoya: Surgery, Gyn. and Obs., 1917, Vol. xxiv, 370.

jected (2 oz. of ether to a pint of saline). It was found that this concentration produced a transient hemoglobinuria. Test tube experiments of a 5 per cent. solution (1 oz. to a pint of saline) mixed with blood showed no laking. A count of red cells taken at intervals during operation showed no hemolysis. Later experiments indicated that a 7 per cent. solution was equally free from risk. The advocates of the intravenous method of etherization contend that by thus introducing ether directly into the circulation a smaller amount is required to induce and mantain anesthesia. In comparing the amount to that used in inhalation and insufflation the fact that a considerable qnantity is lost through evaporation and waste in the latter methods should not be lost sight of. It has been shown experimentally that a certain ratio between the blood and ether must be maintained or the degree of narcosis will vary. As the amount of circulating fluid is increased by the saline in the anesthetic so the amount of ether must be increased to the proportion that the saline bears to the original volume of blood to maintain the same degree of narcosis. If the amount of circulating fluid present is constant the depth of narcosis is influenced by the percentage of ether administered. It is claimed that this method is of special advantage in patients who are likely to be benefited by saline infusion either because of hemorrhage, shock or low vitality.

Coburn[4] concludes: "That in the normal individual about eight ounces of saline are required for induction of anesthesia and consequently at the end of induction there is about 5 per cent. more ether in the system than is required in other methods; at the end of an hour of surgical anesthesia the excess is 15 per cent. At the end of a long operation the excess would be more than doubled." It is readily conceivable that a larger amount of ether may be administered than is actually required to maintain anesthesia, although within the limits of safety. Whether the surplus is in the vessels or tissues it must be eliminated. The late toxic effects may thus be increased. Aside from these objections there appears to be more bleeding and some danger of pulmonary edema. The method will never become popular because of the somewhat complicated technic required in its administration. There is great danger of septic thrombosis unless administered under perfect asepsis.

4. COBURN: Journal, A. M. A., 1914, Vol. lxii, 264.

OPEN ETHER.

THE *OPEN METHOD* of etherization was originated and developed by Dr. Lawrence H. Prince in 1893. At that time he gave a description of the method and reported two series of administrations each containing five hundred patients. The essayist had the good fortune and privilege of being associated with Dr. Prince during his investigations and in 1898 reported her first thousand administrations. As a student and interne and later as an anesthetist she had had ample opportunity of seeing not only the discomfort of the patients during the induction period but the postoperative complications which could be traced to the ether narcosis. It is not surprising then that a method of anesthesia which eliminated the disadvantages of the one in use was hailed with delight and immediately adopted. After a very large experience I can say now in all truth that I have reason "for the faith that is in me." The superiority of the method is evidenced by its steady growth in popularity.

According to the statistics of the Committee on Anesthesia of the American Medical Association more than half of the ether anesthesias administered from 1905 to 1912 were by the open method. This method of administration does not preclude sequence or combined anesthesia if desired, nor does it mean that the anesthetic cannot be selected to suit individual requirements. Furthermore, the simplicity of the method should not argue against its efficiency.

TECHNIC OF OPEN ETHER.

THE MANNER IN WHICH ETHER is administered during the induction of narcosis spells comfort or discomfort for the patient and makes for his future attitude toward anesthesia. Ether may be given as a sequence to nitrous oxid and oxygen which doubtless is the most agreeable method for the patient. However, many hospitals are not equipped with an apparatus for the administration of nitrous oxid and oxygen, consequently a method which gives the greatest amount of comfort to the patient and at the same time is safe is most desirable. Ethyl chlorid and ethyl bromid may be given in place of the nitrous oxid and oxygen. They possess the advantage over nitrous oxid and oxygen in that they are more easily carried about and require no special apparatus for their administration, but the mortality attendant upon their use is so high that few anesthetists care to assume the extra risk of administering them.

Preparation of the field of operation during the induction of anesthesia serves a double purpose: it shortens the length of narcosis and helps to divert the mind of the patient from the anesthetic. The confidence and cooperation of young children as well as adults can be readily secured if a moment is taken to explain what you are going to do and why you are doing it. Make the patient feel that you are not unmindful or careless of his anxieties and you will be more than repaid by seeing him relax his muscles, smile and not infrequently say: "All right, I'll do anything you say if you will promise to stay with me throughout the operation."

Before beginning the anesthetic the patient is told to breathe naturally, not to force his respiration, and while the mask is held away from the face the ether is slowly dropped on various points of the cover. As the patient becomes accustomed to the odor the mask is gradually lowered now increased until the entire cone cover is till it rests on the face. The rate of dropping is moist. In a few minutes a piece of gauze is placed around the cone or the cone may rest on a gauze ring pad which encircles the nose and mouth, to shut out the air which passes under it; thus all the air which the patient receives is more or less impregnated with ether vapor. When the cone cover is too thick, as, for example, when two layers of stockinet and ten or twenty layers of gauze are used, the method ceases to be open and may be termed the semi-closed method. With the latter technic more ether is required to moisten the cover, and the patient's exhalations to a considerable degree are retained within the cone and are reinhaled. The oxygen supply is thereby greatly diminished, the effect of which is shown by more or less cyanosis. Two layers of fine, closely woven stockinet or its equivalent in gauze is all that should cover the mask. Stockinet makes a better evaporating surface than gauze. If the cover is too thin it is difficult or impossible to induce and maintain anesthesia. The ether should be dropped continually on the cone. If the dropping is suspended till signs of returning consciousness appear an uneven narcosis results. Intermittent administration has the further disadvantage or danger of administering a too concentrated vapor in one's haste to get the patient *under* again. It should be remembered that a concentrated vapor will do more injury to lung epithelium in a few minutes than a dilute vapor will do during a long anesthesia. It has been shown that a 6 or 7 per cent. vapor is the greatest concentration which can be inhaled without irritation to the air passages. The depth of narcosis is controlled by the amount of ether dropped on the cone and can be varied to suit the operative requirements. To have the cone more than saturated is a waste of ether, as it runs off the cover. When the proper technic of the open method of etherization is carried out, narcosis develops along the lines of natural sleep and it is a rare exception not to have a smooth anesthesia with relaxed muscles and perfect oxygenation throughout the most difficult operation. Contrary to the teachings of some anesthetists, we have no hesitancy in saying that, barring operations which call for insufflation (intrapharyngeal, intratracheal) anesthesia, the open method is suitable for any patient or any operation in which ether is the anesthetic of choice. We have employed this method of anesthesia with equally good results at all ages ranging from thirty-six hours (spina bifida) to ninety-six years (carcinoma of the face) and in all conditions of health from the marasmic infant to the athlete, from the frail patient suffering with severe heart lesions to the obese alcoholic. From observation of the work of other anesthetists and as an instructor we have found that trouble during induction and maintenance has invariably been due to faulty technic and not to the open method of etherization.

It is a mistake to think that this method is *fool-proof*. An overdose of ether can be easily given, although the danger is not so great as when less air is allowed as in the rebreathing or closed methods.

ADVANTAGES OF OPEN ETHER.

THE SUPERIORITY OF THE OPEN METHOD of etherization does not rest upon faith but upon demonstrated facts. One of the greatest, if not the greatest advantage which this method possesses is the large amount of oxygen which the patient constantly receives. This fact is readily determined by observing the ears, face and color of the blood. There is not an intermitting pink and duskiness as when the rebreathing method is used, but the blood oxygenation is constant and normal throughout the narcosis. It therefore naturally follows that the toxic effects are lessened and this has been shown to be the case. Gatch's[5] studies lead him to the conclusion that: "The severity of the pulmonary lesions found after experimental etherization by the closed method can be satisfactorily accounted for by the great concentration of the ether vapor and the greater liability to aspirate mouth contents when these are used." Dresser[6] found that: "The ether vapor within the closed mask sometimes reached a concentration as high as thirty-four per cent. while 6 or 7 per cent. is the strongest concentration which can be inhaled without irritation to the air passages." He regards any concentration of vapor which cannot be inhaled by a conscious patient without coughing as harmful to the lung epithelium. Poppert[7] likewise concluded from his experiments that the greater the ether concentration the more irritating to the lungs. Offergeld[8] studied the pathological changes in the lungs which occurred after an etherization lasting from seventy to eighty minutes. His results were obtained in guinea-pigs, rabbits and cats after using the closed method, a mixture of ether and oxygen and by the open method. The animals which did not die were killed at various periods after the narcosis. With the closed anesthesia some of the animals died in a few days from bronchopenumonia. Some were killed in two or three days and their lungs showed patches of bronchopneumonia, fatty degeneration and desquamation of bronchial epithelium and hemorrhage into the alveoli. None of the animals that were given ether and oxygen died. If killed at the end of the first day, patches of consolidation with some blood and desquamation of epithelium were present in the bronchi. With the open method there were no deaths. Two days after the anesthesia, necropsy showed a perfectly normal condition of the lungs. When the closed method was used it required four days for the mildest cases to repair. The difference in anesthesia as maintained by the open and closed methods is quite apparent. When an asphyxial factor is introduced the accessory muscles of respiration assist in the effort to obtain a sufficient supply of oxygen. The result is labored breathing with more or less heaving abdominal movements. The presence of anoxemia is evident by the congestion of the venous system as shown by the bluish color of the ears, lips, cheeks and blood. The respiratory tract is especially affected by the general venous engorgement which increases the size of the tongue and surrounding structures and thus a mechanical obstruction is produced which is further aggravated by the increased flow of mucus. Closed ether administration is particularly unsuitable for florid, stout persons, who become alarmingly cyanosed when subjected to air limitation. When an abundance of air or oxygen is allowed there is no congestion of the capillary vessels and consequently there is little oozing of venous blood from the wound. The pulse

5. Gatch: Journal A. M. A., 1911, Vol. lvii, 1593.
6. Dresser: Bull., Johns Hop. Hosp., 1895, Vol. vi, 7.
7. Poppert: Deutsch. Zschr. f. chir., 1902, Vol. lxvii, 505.
8. Offergeld: Arch. f. Klin. Chir. 1898, Vol. lvii, 175.

is of good volume and blood pressure is well maintained.

FALL IN TEMPERATURE.

IN A SERIES OF PATIENTS anesthetized by the open method we found the temperature (rectal) following operations lasting thirty-five minutes or more, averaged a fall in the male patients of 0.67 F and in the females 0.27 F. The patients upon whom these observations were made were well covered, as is our custom, during the operations, the parts to be operated upon alone being exposed. Davis and McCarty[9] in a recent publication call attention to the fall in temperature during natural sleep. The observations were made upon children who were without fever and without ailments which might cause variations in temperature. The rectal temperature was taken just after the child had fallen asleep and again after an interval of two hours without waking the child. The fall during two hours sleep was 0.9 F. in the males and 0.41 in the females. Why the fall is so much greater in the males than in the females in both series we are unable to explain. It will be observed that the fall during natural sleep is twice as great as that during narcosis and as these authors suggest it is possible that the decrease in body temperature during etherization is analogous to that occurring in natural sleep. (See this Year-Book.)

WARMED ETHER VAPOR.

THAT THERE IS ANY VIRTUE in warming ether vapor to body temperature is questioned by such able observers as Sellig,[10] Meltzer, [11] Cotton and Boothby,[12] Bevan,[13] McCarty[9] and Davis and others. However, inasmuch as it is considered of value by some anesthetists an investigation was instituted to determine the temperature of the vapor within the cone at the point of inhalation.

The thermometer was so arranged that it did not come in contact with the patient's face. It was found that the average temperature was about 87.6 F., that is, relatively near body temperature. McCarty and Davis[9] have shown that, "A further increase of heat is gained by the time the mixture has reached the pharynx, so that the entire warming process is accomplished before the anesthetic enters the respiratory tract proper." The space within the cone to some extent forms a mixing chamber for the vaporized ether and air. This space also allows a slight degree of rebreathing, the amount of which depends upon the thickness of the cone cover. It naturally follows that the thinner the cover the less rebreathing there will be and the more oxygen the patient will receive. We have found that in vaporizing ether for intrapharyngeal insufflation that there is an advantage in warming the liquid ether; not because of any value in warm vapor but because when air is forced over or through liquid ether the warm ether vaporizes more readily and consequently less air is required to carry the same amount of ether.

PRESERVATION OF BODY HEAT DURING ANESTHESIA.

OF MUCH GREATER IMPORTANCE than warming the ether vapor is the conservation of body heat during anesthesia.[14] Vierdort[15] gives eleven calories per hour as the normal elimination of heat by the lungs, and ninety calories by the skin. When these figures are contrasted, the necessity of preventing the loss of heat by the skin through radiation, evaporation and conduction is apparent. The loss of heat can be prevented by covering, or even raised above normal if the patient is surrounded by hot bottles.

A word regarding ether may not be amiss. Any ether which forms *snow* on the cork or wick when left standing or which freezes on the cone cover during administration should be discarded as being unsuitable for the open method of anesthesia. With such an ether it is difficult, often impossible, to maintain an even, smooth anes-

9. Davis and McCarty: Am. Journal of Surgery, Anaes. Sup., 1917, Vol. xxxi, 46.
10. Sellig: Interstate Medical Journal, 1911, Vol. xviii, 927.
11. Meltzer: Med. Rec., New York, 1910, Vol. lxxvii, 477.
12. Cotton and Boothby: Sur., Gyn. and Obs., 1912, Vol. xv, 724.
13. Bevan: Journal A. M. A., 1915, Vol. lxv, 1418.
14. Herb: Journal A. M. A., 1916, Vol. lxvi, 1376.
15. Vierdort: Daten und Tabelen für Mediziner.

thesia and, furthermore, a much larger quantity is required which offsets the difference in price.

CONCLUSIONS.

1. When ether alone is administered the induction of narcosis by the open method of etherization is comparatively comfortable.

2. With the open method of etherization, the blood is well oxygenated throughout the narcosis and the patient leaves the operating table with normal respiration and normal color.

3. Barring operations which call for insufflation anesthesia the open method is suitable for any patient or any operation in which ether is the anesthetic of choice.

4. Experimental evidence shows that with the open method of etherization there is less injury to the lung epithelium than when the closed or semi-closed methods are employed.

5. Trouble during induction or maintenance of anesthesia is invariably due to faulty technic and not to the open method of etherization.

6. The conservation of body heat narcosis is of greater importance than warming the ether vapor.

IN OUR MODERN ENTHUSIASM FOR ORGANIZATION WE ARE IN DANGER OF FORGETTING THAT SYSTEM AND SURVEY AND ENCYCLOPEDIC KNOWLEDGE CAN NEVER SUPPLANT REAL THINKING. THINKING IS, AFTER ALL, AN INDIVIDUAL PERFORMANCE. COMPANIES OR GROUPS OF PERSONS DO NOT THINK TOGETHER OR DEVISE OR INVENT ANYTHING OR ANY PROCESS EXCEPT IN SO FAR AS THEY PUT TOGETHER, ORGANIZE AND COMPARE THE PRODUCTS OF INDIVIDUAL MINDS. WE MUST NOT BECOME BLIND TO THE LIMITATIONS OF ORGANIZING INVESTIGATIVE EFFORT. A PLEA FOR THE INDIVIDUAL WORKER IN SCIENCE IS TIMELY. HE MUST BE ENCOURAGED AND PERMITTED TO UNFOLD HIS OWN PERSONALITY AND POINT OF VIEW WITH AN OPEN MIND RATHER THAN TO BE BIASED BY THE PROJECTS OF A COMPANY OF SCHOLARS. LET US BY ALL MEANS FACILITATE THE PROGRESS OF SCIENCE BY FURNISHING THE REQUISITES FOR RESEARCH; BY ORGANIZED EFFORT TO PROMOTE THE AIMS AND SET FORTH THE RESULTS; BY SYSTEMATIC PLANNING AND COOPERATION WHICH WILL MAKE ESTABLISHED FACTS EASILY AVAILABLE AND WIDELY KNOWN. BUT AMID THIS GROWTH OF THE GET-TOGETHER SPIRIT AND BETTER INTELLECTUAL COMMUNITY LET US ALWAYS BEAR IN MIND THE INDIVIDUAL WHO DOES THE THINKING. GENIUS IS FOUND IN MEN, NOT IN ORGANIZATIONS.

—*Journal A. M. A.*

ANESTHESIA IN HUMAN BEINGS BY INTRAVENOUS INJECTION OF MAGNESIUM SULPHATE . PREVIOUS EXPERIMENTAL OBSERVATIONS . USE OF MAGNESIUM SULPHATE IN TETANUS . USE OF MAGNESIUM SULPHATE FOR OPERATIONS ON PATIENTS . CASE REPORTS . SUMMARY OF RESULTS .

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ONE OF THE SUBJECTS which has interested Samuel J. Meltzer, of New York City, has been the therapeutic use of the magnesium salts. He and his co-workers developed a wide field of utility for magnesium salts after prolonged experimental study. After the use of magnesium sulphate had become prevalent in the treatment of tetanus Meltzer, working in the Rockefeller Institute and Charles H. Peck, working in the clinics of the Roosevelt Hospital attempted to adopt magnesium sulphate as an agent for intravenous anesthesia. They reported on their observations to the American Medical Association and the American Association of Anesthetists, at Detroit, in June, 1916, and published their initial case reports in the Journal A. M. A., October 15, 1916. Their observations are reprinted on account of their novelty and the fact that this method of anesthesia may yet come to be used in certain types of cases.

In this preliminary communication, write Peck and Meltzer, we wish to report briefly the course of anesthesia in three operations performed on human beings exclusively under the influence of an intravenous injection of magnesium sulphate. The object of this report, is at least for the present, essentially a theoretical one. These few observations, although far from being sufficient to demonstrate the practicability of this method of anesthesia, are completely sufficient to establish the theoretical question regarding the nature of the anesthesia produced by magnesium sulphate. Furthermore, the theoretical information thus obtained is an indispensable step in the development of the practical application of this method. In order to undersand the question under discussion, a brief historical statement of the various phases in the progress of this investigation is necessary.

PREVIOUS EXPERIMENTAL OBSERVATIONS.

IN A SERIES OF EXPERIMENTS on the effects of intracerebral injections of solutions of various salts carried on some eighteen years ago on rabbits by one of us, it was observed that an intracerebral injection of 2 drops of a 5 per cent. solution of magnesium sulphate produced complete anesthesia and relaxation of the animal lasting several hours. On the basis of the hypothesis that magnesium is an inhibitory factor in the life phenomena, this observation led to a prolonged experimental study of the effects of magnesium salts on the animal body and to many publications on this subject. In their first publication in 1905, Meltzer and Auer made the general statement that the salts of magnesium are capable of depressing the entire nervous system, and assumed in particular that these salts are also capable of producing anesthetic and other central effects. Since this first publication, quite an extensive literature grew up on the subject. Some of the writers insisted that magnesium exerts only a curare-like action, that is, the salts paralyze the motor nerve endings to such a degree that the animal is incapable of responding to any stimulation; in other words, that the animal which appears to be anesthetized is actually conscious during the operation and feels all the pain inflicted on it, but is incapable of manifesting its sensations on account of the complete paralysis. Against this assumption it is to be mentioned that in the course of their experimentation on animals, Meltzer and Auer found, among others, that a combination of ether inhalation and intramuscular injections of magnesium salts, in small ineffective doses, produces a profound anesthesia. Peck and Meltzer found this to hold true also for human beings. Since the amount of ether used in these cases was absolutely insufficient to produce anesthesia, the additional effect of magnesium is apparently of central origin. While thus these observations made the assumption of the central action of magnesium highly probable, it could not be claimed that it has definitely proved it for reasons which cannot be discussed here in detail. Studies of Auer and Meltzer on the effect of intravenous injection of magnesium sulphate on the various stages of the action of the center of deglutition seemed to prove definitely that magnesium affects also the center of deglutition. While these observations seem indeed to prove definitely the central nature of the action of magnesium salts, it could still be assumed that the fact that magnesium salts affect some parts of the central nervous system cannot serve as evidence that these salts affect also the sensation of pain and the consciousness.

USE OF MAGNESIUM SULPHATE IN TETANUS.

EVIDENTLY A RELIABLE PROOF for the assumption that magnesium is capable of abolishing consciousness can be obtained only from observations on human beings. Intravenous injections of magnesium sulphate into human beings were made about a year ago in several cases of tetanus. Whether or not the consciousness of the patients was affected could not be learned from the meager descriptions of these cases. At any rate, these cases have the merit of the demonstration that certain amounts of magnesium sulphate can be given intravenously to human beings without endangering their life. Furthermore, in two or three of the cases the amount injected was surely not too small. In a recent series of experiments on intravenous injections of magnesium sulphate into dogs, Auer and Meltzer studied the quantity of magnesium which may be introduced without danger to the animal, and which would, at the same time, be capable of producing apparently profound anesthesia.

From the recent extensive experience on the use of magnesium sulphate in cases of tetanus, we gained the general impression that human beings are more susceptible to the effects of magnesium salts than animals. In trying to study the anesthetic effect on human beings of magnesium sulphate, administered intravenously, it was therefore necessary that the observations should be made with great caution, beginning with injections of only small doses. The dose of nagnesium sulphate used in our first case was much smaller than some of the doses used for many hours with apparent impunity by Straub in his tetanus cases. We may add, further, that in our studies the patient was provided with two reliable safeguards against the prominent toxic effect of an overdose of magnesium salts (that is, respiratory paralysis): we had in readiness an apparatus for administering efficient artificial respiration, and had on hand a proper solution of calcium chlorid to use as a prompt antidote for the restoration of respiration.

USE OF MAGNESIUM SULPHATE FOR OPERATIONS ON PATIENTS.

THE PATIENTS WERE PREPARED for the operations in the usual way, except that they did not receive the usual preliminary injection of morphin. In all three cases the cubital vein was exposed and a transfusion needle inserted directly into it. This preliminary slight operative procedure was done under local anesthesia. The magnesium solution was run into the vein through the transfusion needle from a graduated buret arranged on the principle of Mariotte's flask. The number of bubbles appearing in a unit of time at the lower end of the inner tube permits a general estimation of the rapidity of the infusion. This, however, was more reliably controlled by frequent reading of the quantity of magnesium which escaped from the buret in one or two minutes at a time.

Case 1.—March 30, 1916, G. F., Italian, weighing about 160 pounds, was operated on for glandular abscesses in the neck. A 6 per cent. solution of magnesium sulphate was used in this case. The infusion began at 4:29 and was finished at 5:14 p. m. Altogether 180 cc. of the solution were infused in forty-five minutes, 80 cc. of which however, were infused in the course of the last eleven minutes, which means at an average of 8 cc. per minute. Shortly after the infusion was started, the patient began to complain of feeling hot; his face became very much flushed, and his forehead was covered with beads of perspiration; there was no nausea. At 4:45 the pulse was 104, and respiration 28 per minute. At 4:56 the pulse was 120, respiration 32. At 4:59, pulse 100, respiration 36. At 5:04, pulse 100, respiration 28. At 5:07, pulse 112, respiration 20. At the end of the infusion, pulse 112, respiration 28.

The operation was begun at 5 p. m. The patient was fully conscious, but sensation was considerably diminished. He made no attempt to interfere with the operation. During the last seven minutes of the operation, the patient showed no indication of feeling pain, and manifested only slight signs of consciousness. The lid reflex was prompt. He remained very drowsy for about fifteen minutes after the operation. He responded slightly to loud calling. He said that he felt weak.

Twenty minutes after the operation the patient was fully awake. He said that he felt a "little bit of pain" during the operation. He was very thirsty, and had a glass of ice water. He had no nausea. There were no after-effects of the anesthesia, and the patient made an uneventful recovery.

During the last part of the operation the patient was practically under complete anesthesia and had evidently no knowledge of what was happening to him. His later statement that he felt a "little bit of pain" referred to the first incision. Respiration and lid reflexes remained practically unaffected. While there was later some muscular weakness which may have had its origin in the action of the magnesium on the endings of the motor nerves, this peripheral action was evidently far behind the inhibitory action which the infusion of the magnesium solution exerted on pain, sensation and consciousness. At any rate, even this case clearly demonstrated that the magnesium solution exerts a genuine central effect which is entirely independent of any peripheral action which may or may not be present.

Considering the weight of the patient, it must be emphatically stated that he received a very small dose of the salt, a dose which would be absolutely insufficient to produce a similar effect on an animal. A dog of 10 kg. (one eighth of the patient's weight) which would receive 23 cc. of the same solution (about one-eighth of the solution given to the patient) in the course of forty-five minutes would hardly show any depressive effects.

Case 2.—May 2, 1916, A. S., weighing 120 pounds, was operated on for varicocele. The infusion of a 6 per cent. solution of magnesium sulphate was begun at 4:20 p. m., and terminated at 5:08 p. m. In forty-eight minutes, 394 cc. were infused. The average of velocity of infusion was 8.5 cc. a minute. From 4:46 to 5:05, however, 235 cc. were infused, which is at an average of 12.4 cc. a minute. Furthermore, in the one minute from 5:04 to 5:05, the large quantity of 39 cc. was infused. In the following last three minutes altogether only 13 cc. were infused. This patient also complained of heat, and his face became flushed and the forehead was covered with perspiration. The patient vomited at 4:46. During the entire infusion the lowest pulse rate was 108 a minute. At 4:58 the patient began to feel sleepy. The first incision was made at 5:00 p. m. At 5:02 the patient was still moving and slightly groaning, but did not interfere with the operative procedure. Anesthesia soon became very deep. At 5:06 respiration was shallow and only 6 per minute. The rate of infusion of magnesium was greatly reduced; respiration immediately became deeper and more frequent, about 22 per minute. At 5:08 the magnesium infusion was stopped completely. The operation was completed at 5:13. In the last five minutes of the operation the patient had no infusion of magnesium solution. At 5:15 10 cc. of a 2.5 per cent. calcium chlorid solution were infused. There was no need for it, as the respiration was fairly good, but the injection of the calcium solution deepened the respiration visibly. At 5:19 the patient answered questions. He opened his eyes at 5:20 and was apparently fully awake. He stated that he felt no pain whatsoever during the operation. He was very thirsty, and had two glasses of ice water. No nausea or vomiting followed. There was no special after-effect from the magnesium infusion. He passed urine spontaneously and freely which was free from albumin, casts, sugar, acetone aud diacetic acid. Twenty-four hours after the operation the patient began to complain of pain in the wound. The temperature rose gradually to 103 F. Pain and high temperature soon disappeared, however, and the patient made an uneventful recovery.

In this case consciousness and sensation were completely abolished for at least ten minutes. The patient had no recollection whatsoever of the operative procedure. The short but very rapid infusion of the solution at a rate of 39 cc. in one minute affected considerably the rate and depth of the respirations, but a reduction in the rate of the infusion caused quickly a return of the respiration to practically normal conditions.

Case 3.—May 26, 1916, H. P., weighing 125 pounds, was operated on for double inguinal hernia. The magnesium sulphate was given in this case in a 10 per cent. solution. Infusion was begun at 4:23 and finished at 5:14; 280 cc. were infused in the course of fifty-one minutes, that is, at an average of 5.4 cc. per minute. However, between 4:39 and 4:52, that is, in thirteen minutes, 169 cc. were infused, which is at an average of 13 cc. per minute. Between 4:52 and 5 o'clock the infusion was stopped. From 5, when the infusion was resumed again, to 5:14, when it was finally stopped, only 20 cc. were infused, that is, at an average of about 1.5 cc. per minute. After about 30 cc. were infused, the patient began to feel hot, was perspiring and became restless. When about 63 cc. were infused, the patient stated that he felt weak. At 4.25 (15 cc.) the pulse was 120, and respiration 22 per minute. At 4:33 (57 cc.), pulse 120, respiration 16. At 4:45 (143 cc.), pulse 96, respiration 24; the operation was started. At. 4:47 (182 cc.), *the anesthesia was very deep; there was no spontaneous respiration; artificial respiration by pharyngeal insufflation was began.* At 4:50 the pulse was small, 96; the patient pale and slightly cyanotic; the pupils slightly dilated and fixed. At 4:52 the magnesium was stopped. From 4.47 to 4:56, for nine minutes, there was no sign of a spontaneous respiration. At 4:56 occasional spontaneous respirations appeared. At 4:58 spontaneous respirations were regular, 20 a minute; the pulse was 90 a minute and bounding. At 5 o'clock the patient's color was good, respiration regular, pulse 120. Magnesium was started again. At 5:03 the lid reflex was still absent; pulse 112, respiration 22. At 5:06 the lid reflex was coming back. At 5:08 the pulse was 118, respiration 20. At 5:10, pulse 100, respiration 22. At 5:13, pulse 96, respiration 26. At 5:14 magnesium infusion was stopped. At 5:21 the operation was finished; the pulse was 108, respiration 27. At 5:31 the patient opened his eyes when spoken to.

He was conscious on return to the ward, very thirsty, and was given 6 ounces of water in ten minutes. There was no nausea and no vomiting. *The patient asked whether he had already been operated on.*

On the second day after operation the patient complained of abdominal pains; the abdomen was moderately distended and rigid. The temperature rose to 102.4 F. The patient was about normal again on the third day, and recovery was uneventful.

In the two days following the operation the urine showed a trace of albumin and many hyaline casts, but no sugar.

During the infusion of the magnesium solution the patient was completely unconscious for about forty minutes; when he came out of the anesthesia he had no recollection of the events of the operation. For at least ten minutes there was no spontaneous respiration; the respiratory function was then maintained exclusively by artificial respiration (pharyngeal insufflation). Under the magnesium anesthesia the lid reflex was absent for about twenty minutes. For a few minutes the pulse became slow, and for from ten to fifteen seconds it was even irregular and at times imperceptible. It is possible that with the concentration used in this case (10 per cent.) the magnesium solution may exert also a cardiac effect. This concentration, therefore, ought not to be used until we have learned more of the effects of magnesium sulphate on human beings when used intravenously.

SUMMARY.

THE OBSERVATIONS MADE in these cases prove conclusively that the state of anesthesia which is produced by injection of magnesium sulphate is actually anesthesia, that is, in this state sensation as well as consciousness is temporarily more or less completely abolished. This central effect may or may not be accompanied by a pronounced paralysis of the endings of the motor nerves of a great part of all skeletal muscles. Evidently, the central effect, especially the effect on the sensation of pain and on consciousness, can be attained with a smaller dose of the magnesium salt than that which is required for a paralysis of the motor nerve endings. The central effect also appears to set in sooner than the peripheral one.

The employment of intravenous injection of magnesium salt as an anesthetic may prove to be indeed a practicable and advantageous method, because, in the first place, it may cause simultaneously a moderate degree of relaxation of the muscular mechanism, and, secondly, because the untoward effects can be rapidly reversed by a careful administration of a solution of calcium chlorid. This method, however, before it can be made practically serviceable, will require a good deal of careful study. We shall, therefore, at least for the present, abstain from a discussion of the possibility of the practical applicability of this method.

ANESTHESIA AT THE FRONT . ORGANIZING THE McGILL UNIVERSITY UNIT . UTILITY OF THE GAS-OXYGEN APPARATUS . VALUE OF OTHER ANESTHETICS . NEED OF SPECIALISTS IN ANESTHESIA IN ARMY HOSPITAL SERVICE . INCIDENTS OF ORGANIZATION, TRAINING AND SERVICE . WITH A FIELD AMBULANCE . THE THIRD BATTLE OF YPRES . THE BATTLE OF THE SOMME . CONCLUSIONS . ANESTHETICS USED . SPINAL ANESTHESIA . THE HEMOGLOBIN INDEX AS A SAFETY-FIRST TEST . METHOD OF HANDLING COLLAPSE . ANESTHESIA FOR WOUNDS OF THE LIMBS OF EXTREME SEVERITY . WOUNDS OF THE HEAD . WOUNDS OF THE ABDOMEN . CAUSES OF FALLS IN BLOOD PRESSURE . USE AND VALUE OF GAS-OXYGEN ANESTHESIA AT THE CASUALTY CLEARING STATION . ROUTINE USE OF ETHER PRECEDED BY CHLOROFORM . USE OF OMNOPON . HANDLING EMERGENCIES . WARMED ETHER VAPOR . SELECTIVE USE OF LOCAL AND GENERAL ANESTHESIA . INDICATIONS FOR GENERAL ANESTHESIA, MORPHIN AND LOCAL . SELECTING DIFFERENT LOCAL AND GENERAL ANESTHETICS . CONCLUSIONS.

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THE FACT THAT anesthetic service was mishandled by the medical corps of all the armies in the World War was due to two causes, (1) because anesthesia was not given the importance it deserved and (2) because anesthetists were not commissioned for special service. The Associations of Anesthetists and individual specialists did their utmost to persuade those in authority to organize the anesthetic service, but in this as in other branches of the service good advice was long in being accepted.

Whenever specialists in anesthesia were placed in charge of anesthetic service it usually met the emergencies and demands of war surgery. Among the reminiscences of those who served as anesthetists at the front none are more interesting than those of William B. Howell, of Montreal, Canada, detailed in an address before the American Association of Anesthetists, during the Sixth Annual Meeting at Chicago, June 9-11, 1918. Howell gave the following account of his experiences:

In the autumn of 1914, the Governors of McGill University, Montreal, offered the Canadian Government a sufficient number of the staff of its Medical Faculty to provide officers for a military general hospital. On the 5th of March, 1915, the hospital, which was known as No. 3 General, commenced recruiting. The Commanding Officer was Colonel H. S. Birkett, dean of the Faculty of Medicine, who had served for many years in the Canadian Militia before the war. Among the officers were specialists in surgery, internal medicine, diseases of the eye, ear, nose and throat, an anesthetist and a neurologist.

ORGANIZING THE MCGILL UNIVERSITY UNIT.

WE HAD AMONG the non-commissioned officers and privates seventeen men who were given their degrees in medicine that spring.

We had also a number of medical students. I may say now that shortly after our arrival in England the graduates were taken from us and given commissions in the Royal Army Medical Corps. Later on the medical students of the 4th and 5th years were ordered to return to Canada to complete their medical education. A number of the men in the primary years managed to break away and join combatant units as officers. Two succeeded in getting into the Royal Navy as surgeon probationers. The public in Montreal were much interested in the hospital and subscribed liberally to the company fund.

We were given two motor ambulances and two four-seated Ford cars. The latter were found to be very useful for pleasure as well as business and many were the delightful trips we took in them before the supply of petrol was cut down and such excursions forbidden.

A Canadian lady living in the United States wrote to us saying that she had heard that anesthetics were needed at the front and offered to buy us a supply. It was suggested to her that she should present a gas and oxygen apparatus. Her answer was that she had made inquiries and had been told that this could be bought for about twenty-five dollars and that she would like to give something which would cost more. When it was explained how much the real cost would be she at once sent a check for $1,000. With this an Ohio Monovalve was bought and a plentiful supply of nitrous oxid and oxygen in both large and small cylinders.

We left Montreal on May 6th and arrived in England after a very uneventful voyage. Shortly after arriving in England most of our officers were sent to different military hospitals for instruction. I was sent with two others to Netley, near Southampton. When we reported for duty there the adjutant said to us with rather a weary air: "Well, gentlemen, I am delighted to see you, but I have no work for you and no quarters. You had better find billets in Southampton." So for three weeks we had nothing to do but amuse ourselves, which we did to some purpose, exploring the New Forest and making trips to London, the Isle of Wight, Salisbury, including Stonhenge, and other places.

We arrived in France on June 18th and after a short train journey were dumped down at a small country station near which were some British tent hospitals. Our camp ground was between two of these. The area assigned for officers' quarters was in a ploughed field and here we were soon at work putting up our tents. It was six weeks before we were ready to receive patients. During that time we were erecting the Indian Durbar tents supplied to us. These are huge marquées, some of them capable of accommodating 60 beds. They are made of cotton in several layers and really consist of one tent inside another. At the same time the operating room was built. This contained space for three tables. During such times as we were busy these were in use simultaneously all day long.

UTILITY OF THE GAS-OXYGEN APPARATUS.

WHEN THE GAS MACHINE was ready for use it was one of the stock sights for distinguished visitors. Great were their wonder and admiration. As many of you know, the English apparatus for gas and oxygen is of a rather primitive type. So far as I know they have none which will supply a steady flow of gas at a uniform pressure. *We used our apparatus a great deal. It was especially useful in patients who were in very bad condition. Many of these cases were suffering from gas gangrene or other form of severe sepsis. It was also very useful in the wards for painful dressings, especially cases of compound fracture of the femur and gunshot wounds of the knee.* We brought over with us the small carriage made for taking the apparatus about. It had the fault of not being strong enough. The carriage, however, had never been intended for use at night, over rough ground. Something in the nature of a wheelbarrow would have been more serviceable.

ORGANIZING THE MCGILL UNIVERSITY UNIT.

MY EXPERIENCE WITH ETHER made me consider it distinctly less useful than in civil practice. English ether seems to be *weaker than American. We, fortunately, brought a supply of Squibb's ether and found it more satisfactory. A soldier, as a rule, takes a large amount of anesthetic. With open ether, especially in the hands of an inexperienced anesthetist, he is liable to use language which it is extremely unpleasant to hear in the presence of nursing sisters. Closed methods were found much more satisfactory when properly used, especially when commenced with nitrous oxid gas. A very satisfactory way is to precede ether with ethyl chlorid, using Loosely's Inhaler attached to Hewitt's wide-bore inhaler.* There is, of course, the trouble of washing the apparatus after each administration. This unfortunately had to be done often in a hurried and perfunctory manner. The anesthetist has to do this himself as the number of nursing sisters and orderlies in the operating room of a military hospital is strictly limited.

I used intratracheal ether frequently and found it very satisfactory. When I was short of assistants I would sometimes put the patient under ether, introduce the tube and leave the patient while I went on with another case. The pharyngoscope issued by the Government was two inches too long but I had it cut down and then it did very well. I know no instrument as satisfactory as Chevalier Jackson's. *I had a fairly large experience with chloroform and found it on the whole the most satisfactory of all anesthetics. At first I used the Vernon Harcourt inhaler. The initial outlay is rather high as it costs twenty-five dollars but the saving in anesthetic is wonderful. I have frequently anesthetized patients for short operations with less than two drachms of chloroform. The chief defect of this method is its slowness as it takes sometimes eight or ten minutes to get the patient under. Recovery, however, was quick and very few patients afterwards complained of any unpleasant sensations. Vomiting was extremely rare.* One of my assistants became ill with appendicitis and had to be operated on. I asked him what anesthetic he would like and he immediately said: "Chloroform, with the Vernon Harcourt Inhaler." He afterwards spoke in the highest terms of his experience.

Another defect of the Vernon Harcourt Inhaler is that the rubber face piece rots very quickly from the solvent action of the chloroform. The latter impregnates the saliva and where the saliva reaches the face-piece rotting soon commences. I also had very satisfactory results with chloroform given on an open mask. I never had a death, though one of my assistants, who had not had much experience in anesthesia, lost a patient. At No. 3 General after I left it there was a death under ether and another under nitrous oxid and oxygen, both apparently due to the anesthetic, but I have no very complete knowledge of the details.

In a certain number of cases I used ethyl chlorid alone for short operations with Loosely's Inhaler. I never found it as satisfactory a method as nitrous oxid and oxygen. It is, however, useful when the latter cannot be obtained and is much more portable.

NEED OF SPECIALIST IN ANESTHESIA IN ARMY HOSPITAL SERVICE.

THERE ARE IN the Canadian Army Medical Corps in England and France not more than four or five specialists in anesthesia. The anesthetic is frequently given by the most recently joined officer, with results to the patient which it is not necessary in this company to specify. The more one sees of the real soldier the more one feels that nothing is too good for him. To increase his comfort and safety I would like to see private enterprise supply modern gas apparatus to all the Canadian hospitals. This cannot be expected from the Government on account of the expense. A specialist in anesthesia might be detailed to go from hospital to hospital to teach the proper method of using gas and oxygen and to make suggestions as to the organization of a proper anesthetic service in each hospital.

If the younger medical officers were kept on anesthetic duty continuously for three months and their work properly supervised, we would not have so many of the wounded dreading the anesthetic more than the operation.

Every expert anesthetist that this Society sends overseas means the saving of a certain number *of soldiers' lives and the prevention of an immense amount of suffering and discomfort.*

The bearing of the British soldier in the operating room is admirable. If he is a walking case he comes in his blue hospital suit, kicks off his heavy boots and jumps up on the table without a word. He does exactly what he is told, is wonderfully appreciative of anything that is done for him and is very uncomplaining.

INCIDENTS OF ORGANIZATION, TRAINING AND SERVICE.

As WINTER CAME on our Durbar tents were found to be unserviceable. There was a great deal of rain with high winds. The cotton became soaked and the tents were either blown down or torn. The muddy soil would not hold the tent pegs. Finally on November 20th, we were notified that we were to close down and admit no more patients. We had then nothing to do but while away the time. This was not very easy to do. The officers' mess was in two marquées heated by braziers which filled the atmosphere with fumes which induced coughing and only warmed those who sat very near them. We slept in bell tents which were comfortable enough when a coal-oil stove was burning, so long as one did not have one's feet on the floor. To leave them there meant they soon became as cold as ice. The best way to be comfortable was to lie on one's bed.

During this time our Commanding Officer received an invitation to send some of his officers to Paris to attend a banquet given by the American Club of Paris. Permission was obtained and eight of us went in our two Ford cars. The journey which took a whole day each way, was very cold and much prolonged by numerous accidents to our tires which were old and worn out. However, it was well worth while as a change from the monotony of camp life. Early in December twelve of our officers, including myself, received orders to return to England for duty at Shorncliffe. Not long afterwards, having applied for a transfer, I was ordered to return to Canada to help in the recruiting and organization of the 9th Field Ambulance. Owing to delay in getting my movement order I arrived in Montreal only four days before the field ambulance left, so that I had two voyages across the Atlantic, both of them very stormy, within a month. On arrival in England about the middle of March, we went into camp at Bramshot. We had a certain amount of discomfort here as the weather was cold and we had to sleep in huts which were not heated or furnished in any way.

WITH A FIELD AMBULANCE.

A FIELD AMBULANCE in the British Army is composed of three sections, A, B and C, each capable of acting independently. Each section is composed of a tent sub-division for operating and dressing station; a bearer sub-division for collecting wounded and a transport sub-division, the personnel of which is drawn from the Army Service Corps. Its function is to take over the wounded from the fighting units and transport them to some place where they can be taken over by a motor ambulance convoy which in its turn takes them to a Casualty Clearing Station. The total personnel is 10 officers, nine of whom are doctors, and 224 non-commissioned officers and men. There are three horse and seven motor ambulances, besides a good deal of other transport wagons of various kinds.

Our time in Bramshot was taken up pretty fully in completing our equipment, medical examinations, and route marches. Within a month of our arrival in England we embarked at a port in the South of England. Here we were kept at anchor for five tedious days waiting for the English Channel to be cleared of submarines. When we landed in France we went immediately to a rest camp where we spent four days, and then we received orders to entrain in two parties. I was in charge of the second party which consisted of two other officers and 72 men. We had first to march at night five miles over roads paved with cobblestones. On arrival at the station, we found a train of interminable length and were rather dismayed to find how small an amount of space was allotted to us. The men were wearing their full equipment and when they entrained each one had to be helped up to the footboard and then forced through the door by hard shoving. The only place to put their equipment was on the floor and this left no room for the men's feet. In addition to the men and their equipment we had to find room for two days' rations, which were issued to us at the station, and which included an enormous cheese. We had a good deal of difficulty in finding room for them. The cheese was put in the non-commissioned officers' compartment and was found, I believe, very comfortable as a footstool. In spite of the discomforts the men were wonderfully cheerful and were never heard to complain. We rumbled along all night and at about 7 in the morning arrived at a famous city where we spent the day. At night we entrained again and had another uncomfortable night, arriving late in the afternoon at Poperinghe which was at that time 8 or 9 miles from the trenches. We were casually informed on getting off the train that the town had been shelled the day before, and this information with the sight of buildings protected with sandbags made us realize that we were getting near the *real thing*.

The next afternoon I started with a small party of men to take over a collecting station in Ypres. As we approached Ypres we saw more and more of the effects of war, such as shell holes in the ground and in roofs, roofless houses and trees torn in half. Finally we arrived at the *Abomination of Desolation*. The collecting station was in the cellar of a big and much damaged building. I cannot recommend a cellar in early April as an attractive place to use as a residence. Most of the time was spent in reading by a dim lamp in a small damp room, which we tried to heat by means of a stove not much bigger than the lamp. During the day we held occasional sick parades, but the work was usually very light. There was little enough to tempt one to wander about outside in times of idleness. It was a molelike and depressing existence.

Behind our building was a battery which would wake up from time to time and start firing. After a few rounds it would stop and then the Germans would retaliate. We used to hear the German shells passing overhead and exploding behind us. It was not so bad when this occurred during the day, but at night it interfered with our sleep and we liked it still less. On fine days when the light was good for observation a good many shells would drop into Ypres during the course of the day. Dull rainy days were comparatively peaceful.

We kept a horse ambulance in the courtyard of the building and stabled the horses in one of the rooms. A motor ambulance was kept standing at the end of a long corridor ready to leave at any minute.

In the evening our rations and mail were brought up. A full water cart would arrive and be exchanged for the empty one. One or more motor ambulances arrived to take part in the clearing of wounded, which was always done at night.

As it became dark the horse-ambulance would start off for a rendezvous where it was to receive its load of wounded from the advanced dressing stations. Being a very large and heavy affair it never went faster than a walking pace. We had in addition to the collecting post an advanced dressing station in a dugout a few hundred yards from the front line. This had to be approached through a mile or so of communication trenches. It was a most *unhealthy* neighborhood. We kept our medical officer here. His turn of duty lasted three or four days. The wounded were collected during the day and were brought down at night in a truck on rails laid in the open. The truck was pushed by stretcher bearers. This duty was dangerous on account of machine gun fire which was turned on from time to time during the night. From the truck the wounded were transferred to the horse ambulance and taken to a point where they could be handed on to the motor ambulances. These quickly whisked them off to the main dressing station which was almost four miles from the firing line. Life for the medical officer there was pleasanter than that nearer the front. The building we occupied had been a convent school and two old Belgian nuns stayed on in it. They spent most of their time making lace and, on occasions when shells fell near, went placidly on with their work.

There was a big gun in the neighborhood, which was familiarly known as *Tin Lizzy*. She was a horribly noisy neighbor on the occasions when she was at work. From time to time the Boche tried to reach her with shells, but never successfully.

It was an exhilarating moment when one got into a motor ambulance to return from the advanced dressing station to our headquarters in Poperinghe. It meant the near prospect of a change of clothes, sleeping in pajamas, a bath in the morning and freedom to amuse oneself during the day. One had, of course, to take one's turn at orderly duty. This meant being about the headquarters for 24 hours, taking sick parades. In one's leisure time one could ride about and explore the neighboring country.

Poperinghe was shelled from time to time in a desultory manner while our headquarters were there and our sleep was broken frequently about an hour before daybreak by bomb raids. When our month of clearing was up we moved to a camp a short distance outside the town. There we had charge of the Division Rest Station. This was a field hospital on a small scale, for patients with minor ailments, who would be able to rejoin their units in four or five days. They were housed in two long huts and slept on stretchers. There was generally enough work to occupy every one during the mornings. The afternoons were devoted to playing games, principally baseball. We had plenty of time to ride about and look up friends in other units. Once a week every man attended a bath parade. The divisional baths were in Poperinghe. The men marched there with their towels and had hot baths. At the same time they were given a change of underclothing and their outer clothes ironed to destry pediculi and the nits.

THE THIRD BATTLE OF YPRES.

WE LIVED A PEACEFUL existence till the 2nd of June, 1916. In the morning of that day we heard that our neighbors, a battery of the Lahore Artillery brigade, had orders to *stand to*. We knew then that something was in the air. At lunch a despatch was brought in to our Commanding Officer ordering us to *stand to* also. News then began to arrive that the Germans were violently shelling the front line of our division and that one of the best battalions in the Canadian Army had suffered very heavily. By midnight our camp was emptied of every available man. Some went up to the advanced dressing stations and others to the main one.

For several nights the work was very heavy. It was believed in England that this might be the beginning of a third battle of Ypres. At first the Germans gained a good deal of ground and inflicted heavy casualties on our division. There were over five thousand killed, wounded and missing. Another Canadian Division came in later, a heavy counter attack was made and nearly all the lost ground was regained. Our field ambulance was singularly fortunate in not having any of our men killed and only a few slightly wounded. In many cases our stretcher bearers had the wounded men they were carrying on stretchers, killed. One of our men was carrying a wounded man pick-a-back when a piece of shell took the wounded man's head completely off. The severe fighting gradually died down, the casualties became less and less and our division was withdrawn from the line to rest and reorganize. I was sent in charge of a tent subdivision to Steenvoorde, a delightful little French town about seven miles from Poperinghe just within the frontier. I had with me two officers of the field ambulance. We looked after the sick of some of the battalions of our divisions, who were billeted in the neighborhood. In our leisure time we rode over to Hazebrouck and Bailleul, both of which places have so often been mentioned in accounts of recent fighting.

One day I received an invitation from my Commanding Officer to return to headquarters outside Poperinghe to play in a cricket match between the commissioned and non-commissioned officers of our field ambulance. I started off on horseback with an orderly and when I began to approach Poperinghe found, to my disgust, that the town was being shelled. I soon began to meet ambulances loaded with civilian as well as military wounded. At the entrance of the town we were stopped by a military policeman and told that the road was closed. We turned back and by making a detour around the outskirts of the town were able to reach camp in time for luncheon. We played our match in the afternoon and while playing could hear the whizz of the big shells going into Poperinghe. After dinner the shelling had stopped and we rode back through the town. The troops had been withdrawn and most of the inhabitants had left, so it presented a forlorn appearance. We had ample opportunity to see the damage done since we had been there last.

THE BATTLE OF THE SOMME.

OUR SECOND TURN of duty in the salient came in August and was very different from the first. The battle of the Somme was then in full blast and the Germans had removed many of their guns. We must have been firing ten shells for their one. The weather was hot and dry so that life in cellars and dugouts was not so uncomfortable.

All the time I was in the field ambulance I never gave an anesthetic, nor saw one given. The first place on the way to the base where operations are performed is the Casualty Clearing Station. The important thing in a field ambulance is to get rid of the wounded as quickly as possible in order to be prepared for more and to be able to move with the division, if necessary. The Casualty Clearing Station is just out of the range of shell fire. It is a field hospital which is less mobile than a field ambulance. As a rule only urgent cases are operated on or were at that time, the rest being put in the train and sent as quickly as possible to a base hospital.

CONCLUSIONS.

IN A SEVERE ACTION a C. C. S. is very busy and I cannot imagine any place where the services of a skilled anesthetist would be more useful. A C. C. S. cannot, however, afford to have too much cumbersome apparatus as when the army moves, it moves too.

Later on in the year 1916, I was sent down to the base again to join No. 1 Canadian General Hospital, which was in need of an anesthetist. There at times the work was very heavy from the Somme fighting. We had four operating tables going simultaneously. One day we had over 70 operations. A few days before we had admitted 760 wounded within 24 hours. There were a great many severe chest wounds. I found the surgeons had a preference for opening empyemata, in bad cases, under nitrous oxid and oxygen. I became convinced that this was, with the apparatus we had, the worst possible anesthetic to use, and urged the use of local anesthesia. I saw very little spinal anesthesia used, though I believe it is popular in some hospitals. At the Duchess of Westminister's Hospital at Le Touquet the anesthetist used intravenous ether with, I believe, most satisfactory results.

One of the after-effects of the war will be that the world will be flooded with young men who will call themselves surgeons. A youngster straight from college or who has had a few years of country practice is put in charge of a surgical ward and is allowed either by press of work or by lack of vigilance on the part of the officer in charge of surgery to do an amount of operating, to which he is not entitled by his training or his capabilities. Before he has had time to see the effect of his work his cases are evacuated to another hospital. The patient does not know who he is. There are no critical neighbors or relatives to bring his mistakes home to him. He, therefore, develops self-confidence much more quickly than knowledge, skill or judgment.

Moreover, his pay remains the same whether he works hard or does nothing, and if he is not very conscientious he is liable to do as little as possible and to get careless about the little he does.

Military surgery will make some men into good surgeons, but it will be the spoiling of the medical careers of many more.

When one looks back at the time spent at the front, one remembers most easily the good times, the good comradeship, the merry parties and the making of new friendships. It fortunately takes a certain effort to recall the long periods of intolerable boredom and home-sickness.

To anyone going with the army, I would give one piece of advice—do not worry about getting a large number of hand-knitted socks or the last pattern of sleeping bag or water bottle. It is not these which will make you comfortable. The important thing is to go with congenial associates. Devote your attention before you go to getting into the same unit with one or more tried friends.

THERE ARE NOT many anesthetists, who, in the midst of service were able to devote some of their time and attention to research work and the checking up of their clinical experiences so as to report in a practical way on advances in the science and practice of anesthesia in regard to war surgery. No report that has come to the Editor's attention is more interesting or instructive than that of Goeffrey Marshall, of London, England, presented before the Anesthetic Section of the Royal Society of Medicine, and published in the Transactions of that Society for 1917. Marshall's report is so fraught with significance that it is reprinted in its entirety, as many of his observations are equally applicable to the surgery of civil life.

Surgical operations, writes Dr. Marshall, performed at a Casualty Clearing Station are for the most part urgent. It is often imperative to operate on men within a few hours of their injury while they are still suffering from the effects of shock and hemorrhage. The patients have had to travel some miles from the line by motor ambulance over different roads, and many have been exposed to cold and wet. A correct choice of anesthetic is of the first importance; the patient's life will be as much imperiled by faulty judgment on the part of the anesthetist as by a wrong decision on the part of the surgeon. There are other cases in which the condition is rendered grave by sepsis, especially gas gangrene; but there remains the majority whose wounds are slight and whose general condition is good.

ANESTHETICS USED.

THE METHODS OF ANESTHESIA I have employed are: Ether and chloroform by the open method; ether and chlorofrom by Shipway's warm vapor apparatus; intravenous ether; spinal anesthesia with stovain; nitrous oxid and oxygen; and local infiltration with novocain.

Let us consider the choice of anesthetic in the various types of cases. We will deal first with the lightly wounded, as they are both the most numerous and the least interesting. Our patients have not been prepared for an anesthetic, so that when brought into the theatre the bowel is full and often the stomach as well. In winter months, difficulty is further increased by the prevalence of bronchitis. A large proportion of the men have cough with expectoration. Autopsies on men who have died of wounds, even when they have had no anesthetic, commonly show the lung tissue to be congested while there is excess of secretion in the tubes. In spite of these failings, the lightly wounded are good subjects for anesthesia. They are for the most part young and healthy; they are placid, and have little fear of operation.

The work of the Clearing Station comes in rushes, so that for slight cases the main considerations are *safety, speed and convenience.* The ideal anesthetic is one with which induction is rapid, and recovery complete a few minutes after operation, so that the patient is in fit condition for early evacuation by ambulance train. Apparatus is subjected to much wear and tear, so it should not be complicated or delicate.

Of the anesthetics I have used, gas and oxygen meets these requirements best. Its only drawbacks are that the apparatus is somewhat cumbersome and the materials costly. Local anesthesia can only be employed in a small number of cases on account of the multiplicity of wounds and their lacerated and soiled condition. Ether remains the most generally used anesthetic. The great majority of slight cases are anesthetized by Shipway's warm vapor method. For induction the mixed vapors of ether and chloroform are used; the process is free from struggling, so that it is seldom necessary for an assistant to stand by the patient. It is rapid; in a hundred cases which were timed induction was invariably complete in five minutes. Anesthesia is maintained with ether alone. There is an absence of secretion, and atropin is not given unless the patient has signs of bronchitis. Consciousness is regained quickly, and vomiting has occurred in only 26 per cent. of all cases, including abdominal cases. Since the warm vapor method was introduced in this Clearing Station last winter, the drop-bottle has passed out of use. Compared with the open method there is a saving of at least 60 per cent. of ether. There is much less diffusion of the anesthetic into the atmosphere of the theatre. This is an important consideration to those working in it at times of sustained pressure.

SPINAL ANESTHESIA.

IN CHOOSING AN ANESTHETIC for the more seriously wounded, the one overwhelming factor is safety. We require a method which will not be harmful to a patient and will minimize the shock of operation. It has been urged that spinal anesthesia would meet these requirements and would therefore be of great value in military surgery. For men wounded in the lower extremities I found it a convenient and satisfactory method at a base hospital; cases of profound collapse did not occur. The same good results were obtained at a Clearing Station in all patients who had been wounded not less than forty hours before operation. Of the more recently wounded, however, more than half showed signs of cerebral anemia with great fall of blood pressure shortly after intrathecal injection of stovain. These signs were pallor, nausea, retching, vomiting, and loss of consciousness. More rarely I have seen extreme restlessness, and in one case convulsions. The radial pulse disappears and the patient presents an alarming picture of collapse which may necessitate interruption of the operation. It has been stated that collapse during spinal anesthesia is not dangerous. I have seen two cases in which it proved fatal, and have heard of a number similar fatalities in recently wounded men.

It is to the man whose wounds are less than forty hours old, and who has lost blood, that spinal anesthesia is dangerous. This is shown by an analysis of fifty consecutive cases of wounds of the lower extremities operated on at a Clearing Station under stovain spinal anesthesia. The drug was used in 5 per cent. solution, in most cases glucose. A dose of 1 to 2 cc. was given: when smaller doses were used anesthesia was incomplete, or came on so slowly as to make the method impracticable at a Clearing Station. During injection the patient was placed in either the Barker or sitting position, head and shoulders were kept high for the first fifteen minutes, and then horizontal.

THE HEMOGLOBIN INDEX AS A SAFETY-FIRST TEST.

OF THE RECENTLY WOUNDED PATIENTS, by no means all collapsed under spinal anesthesia. It is important that one should be able to recognize beforehand which cases will tolerate this procedure. Is there any physical sign which will prove a reliable guide? The appearance of the patient is of little assistance, the pulse rate and blood pressure do not help us at all. *A valuable indication is obtained by determining the concentration of the blood.* The method I employ is to estimate the percentage of hemoglobin in the patient's blood by means of a Haldane hemoglobinometer. This method is simple, sufficiently accurate, and only takes a few minutes to complete. A low percentage of hemoglobin—dilute blood—in a man recently wounded, may be taken to mean that he has lost blood. Control observations on healthy unwounded soldiers showed the normal range of hemoglobin to be from 97 to 120 per cent. with an average of about 110 per cent. as against my standard indicator. *In practice I find that if a recently wounded man has a hemoglobin per-*

centage of over 100 it is safe to administer stovain intrathecally. If the reading is below 100 per cent. he will certainly show a serious fall of blood pressure, and symptoms of collapse. In these fifty cases the hemoglobin percentage, blood pressure, and pulse rate were recorded before the injection of stovain. After injection, blood pressure and pulse rate were registered at intervals of about two and a half minutes for not less than fifty minutes. The blood pressure was estimated by means of a Riva-Rocci sphygmomanometer with stethoscope over the brachial artery.

We will divide the fifty cases into three classes:—

Class A.—Men operated on within forty hours of receiving their wounds, whose blood was dilute—hemoglobin under 100 per cent.

Class B.—Men operated on within forty hours of receiving their wounds, whose blood was *not* dilute—hemoglobin 100 per cent. or over.

Class C.—All cases in which a greater interval than forty hours had elapsed between wounding and operation, whether the blood was dilute or not.

In Class A—short interval cases with dilute blood—we have twenty-two examples. Of these twenty-two all but three showed symptoms of collapse after injection of stovain. The average fall of blood pressure was 57 mm. of mercury. In only three cases was the fall of pressure less than 35 mm., the greatest fall was 99 mm.

In Class B—short interval cases in which the blood was not dilute—there are sixteen examples. Of these sixteen, thirteen showed no untoward symptoms whatever after injection. Of the remaining three one complained of nausea, and in the other pallor was the only sign. The average fall of blood pressure was 17 mm. of mercury, and the greatest fall was 33 mm.

In Class C—men wounded more than forty hours—there are six examples. None showed any symptoms of collapse. The average fall of blood pressure was 19.7 mm., and the greatest was 35 mm.

If we divide the cases into classes according to the length of time which elapsed between reception of wound and operation, we find that, until we deal with intervals exceeding forty hours, cases with dilute blood suffer a big fall of blood pressure, while the fall of pressure in cases with blood of normal concentration is less than half as great. When the interval exceeds forty hours the fall of pressure in both types is small and about the same.

I said that neither the blood pressure nor the pulse rate indicate whether a recently wounded man is a suitable subject for intrathecal stovain. We have seen that these cases may be divided into two classes according to whether the blood is dilute or not, and that these two classes react very differently to spinal anesthesia. There is, however, little difference in the average initial pulse rate and blood pressure of the two types.

As regards the appearance of the patient, some of those in Class A were obviously pale but many were not, although estimation of the hemoglobin showed their blood to be dilute. These patients suffered collapse as profound as those in whom loss of blood was obvious clinically. *The deduction I would draw from these observations is that stovain should not be administered intrathecally to men who have been wounded less than forty hours, unless it has been demonstrated that their blood is of normal concentration.*

Whether other drugs, such as novocain, would be equally dangerous I have had no opportunity of determining. We have found the heavy type of solution more satisfactory than that without glucose. The level of anesthesia is more easily controlled when using the heavy solution. As regards fall of blood pressure, results were about the same with the two solutions. The dose of stovain varied from 0.05 to 0.1 grm., and within these limits fall of blood pressure was not proportional to dose of drug. Some of the greatest falls of pressure were associated with the smallest doses of stovain, and *vice versa*. Nor was the fall of blood pressure proportional to the level of anesthesia.

I will leave it to others to explain why men who have recently lost blood should collapse under spinal anesthesia. Perhaps loss of blood is not the only factor. In secondary hemorrhage there is loss of blood without shock of injury.

Do these cases collapse after the injection of stovain? I have had no experience.

METHOD OF HANDLING COLLAPSE.

AS REGARDS PREVENTION or combat of the collapse, the most important factor is position of the patient. Fifteen minutes after injection the head should be lowered, and it should be kept low for at least an hour. The practice of propping the patient up on his return to bed is dangerous. One patient in this series, who had no alarming symptoms when in the operating theatre, was propped up on his return to the ward. He became blanched, pulseless and unconscious. He recovered when the head was lowered, the legs raised, and pressure put on the abdomen. Another patient, whose head and shoulders were raised on his return to the ward, died straightway.

Subcutaneous injection of strychnin appears to be without value, both as a preliminary measure to prevent collapse, and subsequently in its treatment. Intramuscular injection of pituitrin proved useless in combating the fall of blood pressure. Intravenous saline caused temporary improvement in the one case in which it was tried, but the blood pressure fell again after one and a half hours, and the patient died. This last case was a man with a penetrating wound of the abdomen. Our experience of spinal anesthesia for these cases has been limited and unfortunate. Three men with penetrating wounds of the abdomen were each given 0.07 grm. of stovain. In each case the injection was followed by a great fall of blood pressure, and death within a few hours. Lest you should attach undue importance to the personal equation, I should like to say that with spinal anesthesia for appendicectomies our experience has been free from all alarms.

WOUNDS OF THE LIMBS OF EXTREME SEVERITY.

THE TYPE OF CASE I refer to is the man suffering from shock. The wounds are recent, and one or more of his limbs are shattered. His face is pale, and the pulse flickering or imperceptible. Another characteristic of the badly wounded man is his low surface-temperature. If put to bed and surrounded with hot bottles his condition usually improves. The blood pressure is taken every hour, and, if it is rising operation is delayed. This delay must not be too long, or gas gangrene will supervene. The surgeon may be compelled to amputate a limb. and the anesthetist is faced with a pulseless patient who has to undergo a brief but severe operation. The lives of many of these patients may be saved if correct procedure be followed. In the first place morphin should be withheld before operation, or given only in small doses. A recently injured man is particularly susceptible to further shock, and this susceptibility is greatly increased by large doses of morphin. It is my experience that a badly injured patient has a poor chance of rallying if he has received more than ¼ gr. of morphin before operation. *If chloroform be used, the patient is likely to die on the table. With ether the patient's condition actually improves during operation, but he will collapse an hour or two afterwards. If the ether be given intravenously, the patient's condition improves strikingly during administration, but there is profound collapse, which is often fatal, within the next two hours.* The cause of death is not edema of the lungs; in no case have I seen any evidence of this condition either clinically or at autopsy. In several cases there was edema of the liver, and in one patient who died an hour and a half after intravenous ether the gut was edematous from stomach to rectum.

Spinal anesthesia is contraindicated, as I have already shown. *Incomparably good results are obtained with gas and oxygen, and no other anesthetic should be used for this type of case.* Anesthesia may be so light that the patient will move when nerves are resected. There is practically no evidence of shock from the operation, even when this is an amputation through the upper part of the thigh. In only a few of these cases has the blood pressure fallen 15 mm., or the pulse rate risen more than ten beats per minute. The patient is fully conscious five minutes after operation, and can literally "sit up and take nourishment." There is no collapse during the next few hours, and the subsequent progress is notably good.

There is another class of patient who is gravely ill but who is *not* suffering from shock—I mean the septic case. Early sepsis commonly takes the form of gas gangrene. In a typical case the patient vomits repeatedly, his face is of a pale muddy color, his pulse feeble and running. In spite of this apparently desperate condition, such a patient is a much more favorable subject for anesthesia than one who is suffering from shock.

Intrathecal stovain, which causes collapse in the recently wounded man, has no effect on this same man some days later, although sepsis may have rendered his general condition much more serious. This same distinction is seen with ether anesthesia, whether the ether be given intravenously or by inhalation. *The collapse which occurs after operation on a man who is suffering from shock or recent hemorrhage, is not seen in these later and septic cases. Some of the most brilliant results have been obtained with intravenous ether; the improvement in the patient's condition, which occurs during administration, is maintained afterwards, and vomiting seldom recurs.*

Gas and oxygen also give excellent results. Chloroform is to be avoided; if this drug be used the man's blood pressure will fall after operation, and he is likely to die within the next twelve hours.

WOUNDS OF THE HEAD.

THERE IS NOW general agreement that chloroform is a bad anesthetic for head cases. Operation may be performed under local anesthesia; all tissues of the scalp are infiltrated in a circle widely surrounding the site of incision. We generally use a 0.2 per cent. solution of novocain with adrenalin. No pain is felt even when bone or dura are dealt with. On the other hand, the forcible cutting of bone is disturbing to the patient, so that where mentality is unimpaired general anesthesia is preferable. Warm ether vapor is exceedingly satisfactory. The vapor is given by means of a catheter passed down the more patent of the two nostrils; thus the mask is dispensed with and the surgeon has a clear field. The ether is vaporized by passing oxygen through it. Breathing is easy and noiseless and there is no congestion, whatever the position of the patient's head, so that hemorrhage is not unduly provoked.

WOUNDS OF THE ABDOMEN.

IT IS IN THIS GROUP of cases that the warm vapor method has shown to the full its striking advantages. The quiet induction, free from struggling, may save much loss of blood from wounded vessels in the peritoneal cavity. The easy breathing and diminished heat-loss leave the patient in remarkably good condition at the end of a long operation. With regard to heat-loss it is interesting to note that with warm ether vapor I have never seen the so-called ether tremor or shivering fit, which is commonly associated with open ether. The absence of vomiting makes it possible to give fluids by the mouth within two hours of the patient's return to the ward. Men with abdominal wounds are particularly liable to develop bronchitis, perhaps owing to the deficient movement of the lower part of the chest. With open ether 54 per cent. of our abdominal cases had bronchitis after operation. With warm ether vapor the percentage has dropped to 14.7. These figures were obtained from two comparable series occurring in the same months of two successive years; only those cases were counted which survived operation more than forty-eight hours.

CAUSES OF FALLS IN BLOOD PRESSURE.

DURING THE PROGRESS of an ether vapor anesthetic, the blood pressure shows a tendency to rise. *If the operation involves much manipulation of gut and pulling on peritoneum, the pressure will fall.* This fall, however, will be slow, and the process may be continued for hours without reducing the blood pressure to a dangerous level.

Exposure of gut outside the abdmoinal cavity produces a much more serious effect on the patient. If more than 2 or 3 feet of gut are so exposed, after a few minutes the blood pressure commences to fall rapidly and it continues falling until the gut is returned to the abdomen. This effect is seen when the stomach and omentum are exposed, and even with the great omentum alone. *The covering of exposed viscera with pads soaked with hot saline does not prevent this effect on the patient's condition.* Nevertheless it seems probable that the cause is heat-loss from exposed blood vessels. Exposure of gut produces much less effect on a man who is not under an anesthetic. I have seen men arrive from the line with several feet of intestine prolapsed through a wound, yet their blood pressure was within normal limits. In one case more than two-thirds of the small gut had been outside the abdominal cavity for at least four hours, yet this man's blood pressure was 142 mm. of mercury and his pulse rate only 108; the patient recovered. *Surgeons should be urged to make large incisions and work as much as possible with the gut lying inside the peritoneal cavity.*

Apart from copious hemorrhage there is one other procedure which causes rapid fall of blood pressure during abdominal operations. This is turning the patient on his side. The effect is produced only if the patient has been under the anesthetic for a considerable time before being turned. At the end of an abdominal operation the patient may be in good condition; he is then turned on the right or left side, in order that the surgeon may excise a wound in the back. In a few minutes there is a great fall of blood pressure and the radial pulse disappears. It may be hours before the patient recovers this lost ground. *The indication is that wounds of the back should be dealt with before laparotomy, as turning the patient has no ill effect during the first half hour of an ether anesthesia.*

For abdominal cases I give oxygen with the ether vapor; no atropin is administered before operation as I have not been able to discover any advantage from giving it. Ether gives better results than chloroform in these cases. With chloroform the blood pressure falls steadily, and if operation be prolonged the patient may die before the abdomen is closed, or shortly after. *There is one type of abdominal case for which chloroform has advantages—this is the man who has a penetrating wound of the chest as well as of the abdomen.* Here ether cannot be used, as it will, in the majority of cases, provoke fatal intrathoracic hemorrhage. To these patients I now give hyoscin 1-100 gr., atropin 1-100 gr., and morphin 1-6 gr., forty minutes before operation. This is followed by a minimal amount of warm chloroform vapor with oxygen. With this sequence our recovery rate has greatly improved in the chest-abdomen cases, while in the men who died there was no evidence of fresh bleeding into the chest. Still better results are obtained with gas and oxygen, associated with novocain infiltration. (1917.)

With regard to fluids, it has been our practice to give three pints of normal saline subcutaneously during operation. For the collapsed cases this seems to be useless; they do not absorb the fluid. Autopsies on the men who have died as late as thirty hours after operation have shown the bulk of the fluid to be still in the subcutaneous tissues near the site of injection. To these collapse patients we give saline intravenously, toward the end of operation. *Only a very temporary effect is produced on the blood pressure if transfusion is completed in the early stages of operation. I find that hypertonic saline raises the blood pressure, slows the pulse rate and dilutes the blood for a longer period than does the normal solution.* I hope to give definite records illustrating this point at some later date.

In concluding I wish to acknowledge my debt to my commanding officer and to the medical officers of the Casualty Clearing Station to which I am attached. They have given me every assistance in making observation on cases under their care. They have authorized me to say that they are in substantial agreement with the views expressed in this paper. I must add that our views on the choice of anesthetic for the more difficult cases met with at a Casualty Clearing Station are subject to a frequent revision. I welcome this opportunity of provoking criticism from those whose experience is so much greater than mine.

IT WAS IN the surgery of the Casualty Clearing Stations that anesthesia by experts came into its own. Specialists in anesthesia were practically the only ones who could handle the anesthetic service in a way to meet the exigencies and demands of the overwhelming influx of seriously and slightly wounded. Charles Corfield, of Bristol, England, was fortunate in being able to publish his observations from an experience of "Six Months Anesthetic Service at a Casualty Clearing Station on the Somme."

Probably no medical unit in the army has a stronger claim for skilled anesthetists than Casualty Clearing Stations. I was attached to a C. C. S. as special anesthetist, and it may be of interest to give some account of my experiences during the following six months.

USE AND VALUE OF GAS-OXYGEN ANESTHESIA AT THE CASUALTY CLEARING STATION.

ON ARRIVING at the C. C. S., I found the usual anesthetic equipment, *viz.*, chloroform, ether, ethyl chlorid with Schimmelbusch masks. I added to this by indenting for nitrous oxid and apparatus, and fortunately was able to procure them. From my point of view, patients were divided into two classes, those necessitating a short anesthesia, up to 10 or 12 minutes, who were given nitrous oxid, and those requiring a longer period, who were given chloroform and ether. The first class comprised wounds to be cut out and dressed, foreign bodies removed and guillotine amputations, and for such cases nitrous oxid was used. The advantages were both a saving of time and of labor. Time was saved, because the period of induction and returning consciousness were a matter of seconds, rather than minutes, and labor was saved because most of these patients could walk back to their own wards, either by themselves or with the help of one orderly; whereas, chloroform or ether would have meant that every case would be a stretcher one.

For prolonging nitrous anesthesia, one had to use a gas and air mixture. My method was to get them deeply under, and then push back the air valve for a quarter to a third of an inch, so that the patient would get sufficient oxygen to keep him from asphyxiation. Patients varied in the amount they required. It was, one might say, a compromise between color and consciousness; with too much air, they became sensitive to pain, and with too little air they became cyanotic. Occasionally, one came across a patient who was difficult to keep under, because of clonic spasm and rigidity and, in my experience, nitrous oxid is always a difficult anesthetic to give unless the patient can be lying on his back.

I never had any vomiting after this anesthetic, and I daresay most of the patients had a stomach fairly full of food. The condition of the bladder is important, and as so many patients voided their urine while under nitrous oxid, a bottle was given them as a matter of routine immediately before.

I find on referring to the records that average time of this anesthesia was seven to eight minutes, the longest period being 21 minutes. As far as I could roughly calculate, the amount of nitrous oxid used was at the rate of about four gallons a minute.

Nitrous oxid cylinders take up a considerable amount of room. Cylinders carelessly screwed on to the stand lost half their contents by leakage. I, therefore, always fitted them on myself, and tested the joints under water afterwards. I found that greasing the screw-thread with vaseline, and having the cylinder nozzles cleaned of grit and dirt were very effective in making them screw up and so fit accurately. Washers I always cut from a large size drainage tube, and renewed them every time the cylinder was changed. Occasionally, a 100-gallon cylinder would be sent, and as this would not fit the stand, the India-rubber tube connection was screwed directly on to the nozzle and man-handled by a key. This entailed an extra orderly, and so such cylinders were kept for slack days.

We were fortunate in having a dental surgeon with us, who soon picked up the technic of prolonged nitrous oxid administration. In the busy times he proved a valuable help, giving me an opportunity of dealing with the more serious cases and those requiring considerable surgical interference.

ROUTINE USE OF ETHER PRECEDED BY CHLOROFORM.

IN THIS WORK, my routine anesthetic was ether, preceded by chloroform, on a Schimmelbusch mask.

My method of covering the mask was to have an inside layer of lint covered by four or six layers of white gauze.

The ether, when dropped on, soaks quickly through the looser woven gauze, and spreads out over the lint, and the guaze itself, in its cellular texture, enmeshes sufficient warm air from the patient's rebreathing to prevent the whole thing from getting very cold. Before beginning the anesthetic, I dropped about a drachm of chloroform on the inside of the mask, then holding it an inch or so above the patient's face, quietly talked to him and asked him questions. During this time, usually about a minute's duration, the mask would be lowered till it rested on the patient's face. Then ether was cautiously dropped on, gradually increasing up to saturation of the mask as it became tolerated by the respiratory tract. I then placed the corner of a towel, four fold, over the mask to conserve the warmth and increase concentration. By this method, I rarely got the slighest movement on the part of the patient, and he was generally ready for the operator in two minutes from beginning.

This method of giving chloroform means a high percentage at what is supposed to be the most risky period of anesthesia, and is for this reason against the orthodox teaching on the matter. However, during my six months' work, I never had a fatality, or, indeed, any case in which this method gave me anxiety. It had the merit of speed; two minutes, as I have said above, being the usual time to induce complete anesthesia, a record I have never been able to achieve with open ether alone.

USE OF OMNOPON.

IN CASES IN WHICH it was possible, I gave a preliminary dose of omnopon an hour before the operation. The advantages of hyoscin, morphin and atropin for this purpose are common knowledge, and I need not dilate on the method beyond saying that it was particularly useful with us, for it kept patients quiet two or three hours after they had got back to the ward, and so saved the attention of a nurse or orderly.

I was always in favor of patients who could swallow at all having a pint of hot tea while waiting for operative treatment. It has the advantage of stimulating and warming them, they always like it, and it is a very effective *transfusion* too. Being liquid, even if vomited, no mechanical obstruction to respiration is likely to result.

HANDLING EMERGENCIES.

IT IS A CURIOUS thing that in many patients who have had a meal just before they were wounded, the process of digestion or, at any rate of stomach movement, is totally arrested, and they will often vomit food 10 or 12 hours after they have taken it. I remember one patient who, in the first stage of anesthesia, started to vomit violently, and brought up three bowlfuls of bully beef and biscuit. By the time he had finished he was fully conscious again, and I found out from him that he had had this meal 28 hours before, and had been wounded two hours after it.

I was fortunate during my six months' experience in having only one patient die on the table. He had a wound of the diaphragm on the left side, it being partially torn away from the costal attachment. He started with a fairly good pulse, which continued for half an hour, and then gradually got bad; he died in the course of 10 minutes. He was having open ether, and I think death was no doubt due to the abdominal condition.

One case, with considerable damage to the mouth and lower jaw, stopped breathing during anesthesia, and a laryngotomy was done. It was found that a large blood clot had occluded the glottis. He lived and did well. This certainly would have been a suitable case for the intratracheal method, and I think another time I should adopt it, or, failing that, a preliminary laryngotomy.

WARMED ETHER VAPOR.

I MUST BEFORE CONCLUDING, mention the fact that some weeks before I left the C. C. S. I had a Shipway war-ether apparatus in use, Casualty Clearing Stations having been supplied with them. In theory, any effort to conserve the body heat of a patient seriously injured, must be an advantage, and for that reason, the Shipway apparatus justifies itself. I think, too, it is more economical of ether than the open method on a mask. But apart from these considerations, I have not been able to satisfy myself that it has any overwhelming advantage over the drop-bottle and mask. It is more cumbrous, and I find the bellows very tiring for the hand. A foot-bellows would obviate this, and might be added at very small extra cost or weight. Probably, with a larger experience, I should think better of this apparatus, and the authorities, at any rate, are sufficiently impressed with its advantages to send it to each of the hospital units in the field.

This article has been written in England, while home on sick leave, without the aid of notes. It is, therefore, culled from memory and has no statistics.

DURING AN OFFENSIVE when the wounded stream back to the Evacuation Hospital in pressing numbers it is of the utmost importance for those who handle them to understand the use of all methods of general and local anesthesia. The experiences of Henri Vignes, of Paris, France, were such that he was unable to set forth in Progress Medical, May 4, 1918, very definite opinion on this subject. For the benefit of American anesthetists his observations have been editorially abstracted from the French and are herewith presented for the consideration of readers of the Year-Book.

During a recent offensive, writes Vignes, I had charge of handling 471 wounded soldiers, brought direct from the battlefield after the lapse of from one and a half to four hours. All were submitted to whatever intervention was necessary to permit their evacution to the rear. This series included 34 wounded with partial or complete fractures. Others of the blessés required removal of débris, cleansing, drainage and hemostasis, some excision of contused and torn tissue and many extractions of projectiles. Two hundred and two projectiles were searched for and 178 extracted. All but one of the projectiles *not extracted* were in the hands or lungs.

SELECTIVE USE OF LOCAL AND GENERAL ANESTHESIA.

GENERAL ANESTHESIA with ethyl chlorid, ether and chloroform, alone or in sequence, with or without morphin, was used, as was also local anesthesia with cocain, stovain, novocain, neocain with adrenalin and preliminary morphin and also quinin-urea hydrochlorid. General anesthesia was used in 55 cases; local in 198 and 185 injections of morphin were given, usually 0.01 gm., rarely 0.02 gm., ten minutes before operation, and frequently in the neighborhood of the wound. Few of the cases were suitable for regional anesthesia.

We always allowed a lapse of eight minutes for the anesthetic to take effect before operating and with quinin-urea this period was lengthened to 20 minutes. Teamwork in the operating-room enabled us to alternate operations and dressings while the wounded were being anesthetized. Spinal anesthesia was not used.

Ethyl chlorid was used alone for brief anesthesia or in sequence with ether or chloroform. It was sprayed on a compass of gauze closely adapted to the contour of the face. Preliminary morphinization secured a profound and prolonged anesthesia. While there were no untoward complications with general anesthesia, cases in which cocain analgesia proved unsatisfactory, and general anesthesia was substituted, were inclined to show a stage of excitement. In one instance under chloroform anesthesia, while searching for a projectile, a general convulsion followed each time the instrument touched an exposed nerve.

The results with local anesthesia were mostly entirely satisfactory to the patients and operator, and were only so considered when no signs of pain or discomfort were manifested during operation or complained of afterward.

Under local anesthesia, especially with the addition of adrenalin or pituitrin, there was little or no alteration of the pulse rate during or immediately after operation, the maximum difference being about 30 beats, the minimum 2, and the changes were not incidental to any failure of the analgesia. Pituitrin showed a more stabilizing effect on the circulation than adrenalin.

INDICATIONS FOR GENERAL ANESTHESIA.

EXCEPT FOR SIMPLE, PAINLESS DRESSINGS, any other surgical procedure on the wounded in this war, absolutely demands either the use of general or local anesthesia. With Pierre Moiroud I have already emphasized this point. The cleansing, the removal of débris from and the draining of the wound with counter-openings are all operations demanding minute care. It is the present practice to excise all the contused tissues. One cannot do that properly and thoroughly without the aid of anesthesia or analgesia.

Paradoxical as it may seem, anesthesia is the best prophylaxis against shock.

It is the pain of operation added to that of the trauma that is the principal cause of shock. This is in keeping with the researches of Crile. Evidently general anesthesia administered to a shocked patient is an aggravating factor, but the risk is less than that involved in operations without anesthesia. It is most important to conserve the stability of the circulation from nervous shock. There is no sense in being insouciant about inflicting pain under the belief that it is harmless.

INDICATIONS FOR MORPHIN.

INTEREST ATTACHES to the use of morphin in conjunction with both general and local anesthesia. As a preliminary to general anesthesia, morphin decreases the likelihood of excitement during induction and surgical narcosis is more readily secured, while a smaller dosage suffices for maintaining anesthesia. Morphin acts as a prophylactic measure against the incidence of acapnia. It also diminishes postoperative complications. For all these reasons the preliminary injection of morphin, with or without the addition of such circulatory stabilizers as ether, pituitrin, and adrenalin, is an excellent means of diminishing the dangers of intoxication and shock.

R. Picque has well said: "*Anesthesia must be the object of the solicitude of the surgeon. * * * When one has admired the resources in action and the resignation to suffering of those, whom history continues to call the poilus, one cannot tolerate for an instant the thought of their suffering further through a negligence of anesthesia.*"

The results obtained from the preliminary injection of morphin in local anesthesia have always appealed to me.

INDICATIONS FOR LOCAL ANESTHESIA.

MANY AND VARIED surgical procedures can be satisfactorily handled under local anesthesia. I have had no difficulty in excising contused tissues and removing débris; in cleansing the site of fractures, especially those of the tibia, and in removing projectiles deeply imbeded in the thigh, loin and regions of the scapula.

Teamwork in the operating room must be relied on for sorting out the patients that can be best handled under local or general anesthesia. Substituting general anesthesia, after beginning with local, leaves a disagreeable impression on the patient, means loss of time and opens the way to unnecessary infections. It is important then to determine the contra-indications for local anesthesia, both in connection with the site of operation and the lesions that are anticipated.

Vascular regions which bleed freely and others in which dissection are difficult are unsuitable for local anesthesia. When important organs are involved, when tendons and aponeuroses cross the operative field, when it is difficult to see the lesions, or when a retractor is necessary, general anesthesia is indicated.

On the leg the crural space and the popliteal region are least favorable for local anesthesia because they contain important structures and necessitate tedious and delicate dissection. Except for the bulge of the calf the lower leg is unfavorable for local anesthesia on account of the arteries and varicose veins that are encountered, while the instep is crossed with tendons.

The bend of the elbow, the lower arm, the wrist and palm of the hand are regions unsuitable for local anesthesia. The palm of the hand, in particular, is very sensitive. I have repented, on several occasions, searching for even superficially imbedded projectiles in the palm, under local anesthesia.

Deep wounds of the neck must be operated on under general anesthesia.

On the contrary, exploratory incisions of the scalp should be done under local anesthesia. De-Martel advises the employment of novocain-adrenalin for all intracranial surgery of war wounds.

Great discretion must be used in selective anesthesia, as the real conditions of the wounds cannot be anticipated and are often more extended than suspected and require considerable intervention. The violence of the projectiles, the destructive shattering of bones and the hernias of different layers of the musculature cannot be definitely forecast previous to operation. In case of doubt it is better to use general than local anesthesia.

When the symptoms indicate extensive internal destruction of tissues and not merely a perforating tract, general anesthesia is indicated. While local anesthesia may suffice for the anticipated procedure, it not infrequently happens that it is insufficient for accomplishing what is finally necessary for a complete surgical toilette, or what M. Gaudier calls, a complete excision of the wounded area. Such removal diminishes the risks of complications from infection and provides scars which do not interfere with anatomical function.

Injuries of large blood vessels with hematoma, requiring turning out of the clot and ligation, cannot be handled under local anesthesia. If x-ray and the localization of the pain indicate more damage to the soft part than the bone, these cases may be done under local, but in the presence of periosteal involvement, when extended interference is demanded, general anesthesia must be used.

INDICATIONS FOR DIFFERENT LOCAL ANESTHETICS.

COCAIN, NOVOCAIN AND STOVAIN have given us excellent results, but if it is anticipated that general anesthesia must supplement the local, it is better to use stovain or novocain to avoid the cocain excitation during the induction of anesthesia.

For prolonged and extended operations it is advisable to use quinin-urea hydrochlorid on account of its control of after-pain. It should be recalled, however, that quinin-urea diffuses very slightly through the tissues and the injection must be very accurately made.

INDICATIONS FOR DIFFERENT GENERAL ANESTHETICS.

ETHYL CHLORID SHOULD be used whenever possible. A preliminary injection of morphin provides a prolonged operative period. Ethyl chlorid anesthesia presents the great advantage that the wounded operated on shortly awaken to complete consciousness and in consequence can be more readily evacuated to the rear.

The respective indications for chloroform and ether are the same as for civil practice. However, it is important to administer ether in such a way that its volatilization will not be interfered with by the low temperature in which it must occasionally be given in the surgery of war.

CONCLUSIONS.

IT IS VERY IMPORTANT to have specialists in anesthesia at the front.

Anesthesia must not be made an easy berth for the physician who is sent by chance to a military, surgical ambulance. Each surgeon should have his own anesthetist, who should be an expert in his specialty and should be conversant with the most recent advances.

If it is necessary to use members of the ambulance corps to give anesthetics, when a physician is not available, these should have had thorough training in the administration of general anesthetics, especially etherization with an Ombredanne inhaler—a method which minimizes the risks involved.

Familiarity with the stock apparatus provided enhances the results of general anesthesia and if the Ombredanne and Ricard apparatus are both at hand better work will be done.

Warmed vapors, as used by certain American and English anesthetists, induce anesthesia more rapidly and pleasantly, and produce less irritation of the respiratory tract, less nausea, shock and fewer postoperative pulmonary complications. This method deserves study and use, as do other technics, which are at present little known among the profession in France.

IT IS CONSTRUCTIVE WORK THAT COUNTS, THE TANGIBLE RESULTS OF INTELLIGENT, CONSCIENTIOUS LABOR. WE ARE JUDGED BY OUR ACTUAL ACCOMPLISHMENTS, NOT BY WHAT WE MIGHT HAVE DONE. CRITICISM IS VALUELESS UNLESS IT IS INFORMED AND SINCERE. THOSE WHO HAVE FAILED TO MAKE GOOD ARE ENTITLED TO KNOW WHEREIN THEY HAVE FAILED. EVERY COMMUNITY HAS ITS INCURABLE PESSIMISTS. WHILE THEY GRUMBLE ON THE SIDE-LINES, THE GAME OF LIFE IS BEING PLAYED BY MEN AND WOMEN OF FAITH AND COURAGE WHOSE DETERMINED WILL URGES THEM ON TO VICTORY. WE HAVE A RIGHT TO DEMAND OF OUR FELLOWS THAT THEY COMPLAIN LESS BITTERLY OF THE MISTAKES OF THEIR OPPONENTS AND TELL US MORE DEFINITELY WHAT THEY WILL DO IF CONFRONTED BY THE SAME PROBLEMS. BE A BUILDER, NOT A DESTROYER. IT PROFITS NOTHING TO TEAR DOWN ANYTHING THAT CANNOT BE REPLACED WITH SOMETHING BETTER.

—*Meredith Nicholson.*

ANESTHESIA IN WAR SURGERY . A METHOD OF ANESTHETIZING SOLDIERS . EFFECTS OF DIFFERENT MIXTURES OF CHLOROFORM AND ETHER . METHOD OF USING MITIGATED ETHER . PRELIMINARY MEDICATION . COMPLICATIONS . CONCLUSIONS . THE ADMINISTRATION OF ANESTHETIC IN HOME MILITARY HOSPITALS . DETERMINING FACTS . SELECTION OF ANESTHETIC AND ROUTINE METHODS OF ADMINISTRATION . OPEN ETHERIZATION . ANESTHESIA FOR PLASTIC FACE SURGERY . ETHER BRONCHITIS RECORDS . ANESTHESIA FOR SPECIAL CASES . NITROUS OXID-OXYGEN WITH REGULATED REBREATHING IN MILITARY SURGERY . PRE-MEDICATION AND APPARATUS . TECHNIC OF ADMINISTRATION . MIXTURES . REBREATHING . OVERDOSE . POSTOPERATIVE CONDITION . SUMMARY OF CASES . CONCLUSION . ANESTHESIA IN MILITARY HOSPITALS . ANESTHETICS USED AND THE TECHNIC OF ADMINISTRATION . PECULIARITIES OF ANESTHESIA IN MILITARY HOSPITALS . ANESTHETIC REQUIREMENTS IN SHELL SHOCK .

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W. J. McCARDIE, of Birmingham, had long noticed that when coughing occurred during the early stages of etherization a change for a few minutes to chloroform stopped the cough and much lessened mucous secretion. He also found that the small quantity of chloroform inhaled exercised, apparently, a prolonged mitigating effect on the irritating quality of the ether. It seemed to him, therefore, that if the short interval of chloroformization had such a prolonged effect it might be worthwhile to try the addition of a small quantity of chloroform to the ether in Clover's inhaler, with the object not only of lessening irritation but also of obtaining an anesthesia more nearly approaching the ideal —that is, a *sleep-like* one.

In his military work McCardie had an opportunity to put his idea to the test and he reported on his experiences in the British Medical Journal, April 14, 1917. He thus continues his observations:

Since chloroform acts as a depressant, but ether as a stimulant, it should be possible to obtain by a mixed vapor of these two drugs an anesthesia in which, while there is a proper muscular relaxation, the respiratory and circulatory functions are neither depressed nor stimulated but approximate to their condition during sleep. Such a mixture would probably differ in its proportion according as to whether the open or closed method were used, and also according to the type of patient, if the best results were to be obtained. Perhaps the best all-round mixture would be one in which the respiration and circulation are very slightly stimulated by the addition of a little more ether, thus ensuring safety and counteracting any shock arising from the operation. The idea is to take ether as the standard of safety and so to dilute or modify its action as to obtain some of the advantages of chloroform anesthesia. Ether thus modified by chloroform, as suggested later, possesses practically the safety of pure ether. When we use such mixtures as E_2C_1, E_3C_1, we regard chloroform as the main drug and modify its action by the addition of ether. It has been shown of late years that the mixing of chloroform with ether enhances the anesthetic power of each drug; indeed it has been asserted that a mixture of six or seven parts of ether with one part of chloroform increases the potency fully 30 per cent. without increasing the toxicity.

EFFECTS OF DIFFERENT MIXTURES OF CHLOROFORM AND ETHER.

HAVING AT THE First Southern General Hospital, Edgbaston, the opportunity of anesthetizing soldiers—that is, patients of much the same age and type, and trained, fed, and living under the same conditions—I tried the effect of different mixtures of chloroform and ether administered by the closed method from a Hewitt's wide-bore modification of Clover's inhaler. To soldiers a routine method seems particularly applicable. They are mostly strong and fit men, well fed, much accustomed to tobacco and consequently with irritable throats; nearly all have coughs due to exposure to wet and cold indoors and out; their nervous system is on a much higher plane of tension than that of the normal individual during ordinary times, so that altogether as a type they are much more difficult patients in whom to induce anesthesia than are the general run of those met with in civil practice. On the other hand, when once induced, anesthesia is maintained in them more safely and easily than in the ordinary non-military patient, because, generally speaking, of the healthy conditions in which the former have been living. In fact, soldiers more nearly approach the normal healthy human being than does any other class of patients.

At the end of October, 1915, I began to use various mixtures of chloroform and ether in Hewitt's wide-bore Clover's inhaler, beginning with mixtures of E_4C_1, E_7C_1, $E_{10}C_1$, $E_{16}C_1$, $E_{18}C_1$, $E_{20}C_1$, $E_{32}C_1$, by volume.

In the first three of these mixtures the chloroform factor predominated too much for safety, causing blueness and too quiet respiration, while in the last one the ether component predominated too much, and the effect of the chloroform was practically negligible. Finally, in $E_{16}C_1$ I found a mixture which suited admirably my purpose, and have used it in more than 1,200 cases. Since the above-mentioned date it has been my routine method for the induction and often for the maintenance of anesthesia. The $E_{18}C_1$ and $E_{20}C_1$ mixtures I found very useful for debilitated patients.

In 1916 I administered $E_{16}C_1$ to 732 out of 843 cases at the First Southern General Hospital—that is, to practically 7 out of 8 patients.

METHOD OF USING MITIGATED ETHER.

I LOOK UPON IT AS and call it *mitigated ether*, and administer it exactly as I should ether by the closed method, the only difference being that during induction I very often allow one or two inspirations of air.

The respiration and circulation are slightly stimulated, the patient is of a good color, respiration being about half as deep as that during pure etherization. There is much less irritation of the respiratory mucous membranes than with ether alone, but if much coughing ensues during induction, as so often happens in soldiers, I immediately change down to a mixture of chloroform and ether, or more commonly to chloroform alone given by the open method. In fact, in the last few months, in nearly all operations which last longer than a few minutes, save rectal ones, after induction of anesthesia has been safely brought about and some degree of stimulation of the vital functions established by $E_{16}C_1$, I change down to chloroform and find it best suited to maintain anesthesia.

The contraindications to the addition of the small amount of chloroform to the ether are cases in which the fullest stimulation by ether is needed, as in patients in whom there is great shock, loss of blood, or toxemia, or where rapid dilatation of a sphincter or stricture is necessary.

As compared with pure ether, administration of $E_{16}C_1$ by Clover's inhaler causes less irritation, less muscular spasm, less mucous secretion, less excitation, and less obnoxious smell. The induction of anesthesia is quicker and quieter and muscular relaxation appears more quickly and is more complete. The addition of this small amount of chloroform seems to make a very great and advantageous difference. The $E_{16}C_1$ may easily be given without any preliminary administration of nitrous oxid or ethyl chlorid.

PRELIMINARY MEDICATION.

ALL SOLDIERS HAVE a preliminary intramuscular injection of morphin 1/6 of a grain, and atropin 1/100 of a grain, as nearly as possible half an hour before the time of operation, so that the maximum effect of these drugs is obtained. This injection is essential for quiet induction and stoppage of secretion. The effect of the morphin helps greatly to quiet induction and to maintain and steady the anesthesia. It also enables a lighter form of anesthesia to be used than is possible without it. The disadvantage of the morphin is that very occasionally, owing to the light respiration, the patient may become a trifle bluish under chloroform.

Since 1901, when I first used it by the closed method, I gave ethyl chlorid as a preliminary to etherization, but since administering "mitigated ether" it occurred to me that a better preliminary would be a few drops of a mixture of two parts of ether and one part of chloroform dropped into the bag of the inhaler, just as is ethyl chlorid. At first I used to drop the mixture on to a little wad of wool fixed in the angle piece to which the bag is attached, but I soon found it better to spray directly into the bag 15 to 20 drops (not minims—2½ drops are about equal to 1 minim) of E_2C_1. This quantity seems to be equivalent to the usual dose of 3 c.cm. of ethyl chlorid. The few drops of this mixture do not volatilize so quickly as does ethyl chlorid, the vapor does not surge into the head so rapidly, and the transition from the one mixture of chloroform and ether to another mixture of the same components seems somewhat easier, quicker, and smoother than from ethyl chlorid to ether or to *mitigated ether*. The small quantity of mixture so administered is far less costly and more convenient than ethyl chlorid, and I now use it before giving ether in private work.

COMPLICATIONS.

WITH REGARD TO THE course of anesthesia during the administration of $E_{16}C_1$ I have had two cases in which respiration ceased, in one of which the fault was due to inadvertence. In both cases the pulse and color remained excellent, and respiration quickly restarted after a few compressions of the chest. Otherwise I have had no danger or trouble.

With regard to lung troubles I have had four cases of pneumonia and two or three of bronchitis.

All these patients had morphin 1/6 grain and atropin 1/100 grain before anesthesia, and had no mucous secretion; therefore there was no question of inhalation of septic material from the mouth.

Two other patients had a good deal of bronchitis afterwards. There was no prolonged sickness after any administration. It is very probable that in no case was the lung trouble wholly, or even partly, due to the anesthetic, because the patients had to be transferred after operation along draughty corridors to wards which were also sometimes draughty and cold, and were never intended for hospital use.

In the pressure of present-day hospital work rapid induction of anesthesia is necessary. The method described is all round the quickest and least unpleasant one I know, and is practically as safe as the more usual sequences of gas and ether or ethyl chlorid and ether. Refinements and time-spending methods of administration, such as gas and oxygen, intratracheal anesthesia, open ether *ab initio*, percentage inhalers, have little scope and less efficiency when applied to tough fighting men, in the routine of a big and busy hospital. Safe, simple, and speedy methods are the most valuable.

CONCLUSIONS.

1. The irritation caused by ether vapor ad-

ministered by the *closed* method is much mitigated by the addition of a very small quantity of chloroform.

2. The addition of this small amount of chloroform to ether distinctly saves the work of the lungs and heart, which during a long or severe operation may be a very important factor.

3. The mixture is practically as safe as the administration of ether alone, because the ether greatly predominates.

4. It is valuable as a routine method of producing anesthesia in soldiers, being reasonably safe and rapid.

5. A few drops of E_2C_1 are preferable to ethyl chlorid as a preliminary to the administration of ether, or $E_{16}C_1$.

6. For maintenance of anesthesia E_2C_1 or chloroform are preferable to even *mitigated ether*, owing to the prevalence of respiratory irritability among soldiers.

AS CONSULTING ANESTHETIST to the Malta Command and later in a similar position at home, J. F. W. Silk, of London, England, had remarkable opportunities for observing the ins and outs of anesthetic service in military hospitals. He reported on his experiences to the Anesthetic Section of the Royal Society of Medicine, 1918, and his conclusions are of such merit that are herewith given in full.

From the beginning of August, 1915, to the end of July, 1916, I occupied the position of Consulting Anethetist to the Malta Command, that is, during the period of the Gallipoli activities, when the greater part of the beds that the island contained were occupied by surgical cases. For the last fourteen months I have been in a similar position at home, and in that capacity I have visited all, or nearly all, the principal military surgical hospitals in England. In Malta, of course, all the *deaths under anesthetics* were notified to me, and since the middle of January of this year I have received detailed reports of all the fatalities in England, Scotland, and Ireland.

Most of you will recollect, I expect, that in the pre-war days I always deprecated the endeavor to use any one anesthetic, or any one method in every case, and insisted upon the advantages of varying one's procedure in accordance with certain elemental circumstances such as sex, age, physical condition, and nature of the operation. While my views upon this point remain unchanged, I appreciate the fact that the relative values of these resective factors have altered materially under the stress of war. Questions of age and sex have practically disappeared, and the main determining factors are those of the previous condition and the nature of the operation, and even these have very much altered.

DETERMINING FACTS.

FIRST OF ALL with regard to the factor of the previous condition, it seems to me that except for the secondary results of his injury, the soldier may be described as an average healthy male. But these secondary results are of much importance, and introduce factors which are comparatively speaking unknown in civilian practice. For instance, with the acute shock of the battlefield we have but little to do in the home hospitals, but on the other hand, very many of the men are suffering from a condition of *chronic shock* which renders them rather troublesome from the anesthetist's point of view. Then again, many of the soldiers have been the subject of a somewhat prolonged suppuration of varying intensity. This may not perhaps produce all or any of the characteristic objective symptoms of acute sepsis, but I am sure that it has a very bad effect upon the heart muscle. It is rather more than a mere coincidence that of forty postmortems at home the heart muscle was found more or less degenerate in twenty-six, and of these twenty-six there were definite records of prolonged sepsis in twenty. A somewhat similar degeneration, too, results from malarial poisoning, to which the troops are exposed upon some of the fronts. *In Malta the question of the effects of malaria upon the heart muscle and its relation to death under anesthetic was the subject of an exhaustive inquiry by the authorities in that island.*

We do not, nowadays, hear very much about the so-called *soldier's heart,* which was the subject of so much controversy about the time of the Crimean War and after. I am myself inclined to believe, however, that *the dilated heart of over-training and under-feeding is of fairly frequent occurrence, and when by a rare chance such a patient comes under the anesthetic, trouble is very likely to arise.*

As regards the nature of the operation, the differences entailed by war conditions are so obvious that one need do not more than enumerate them. Intracranial injuries are usually treated at the base hospitals abroad, and we see but few at home. At any rate, I know that while I was in Malta such operations were of almost daily occurrence, but I do not think that I have seen a single one since I have been doing home work. Injuries involving the pleuræ are relatively numerous, severe, and complicated. Abdominal surgery, except in point of view of numbers, does not seem to me to differ from similar cases in civil life. *There are, however, at least three classes of case in which the work of the anesthetist has been most distinctly altered and severely tried. I allude to spinal injuries, orthopedic surgery in general, and plastic operations upon the face.*

Looking at the whole subject from a broad general point of view, I should be inclined to say that in military surgery the exceptional cases call more insistently for variations in methods of anesthetization than in civil life. But, on the other hand, the number of normal or straightforward cases is relatively larger. This means of course that our first consideration is the selection of an anesthetic and method which may be employed almost as a matter of routine.

SELECTION OF ANESTHETIC AND ROUTINE METHODS OF ADMINISTRATION.

IN DECIDING this question there are two very important points which must not be lost sight of. The first is the personality of the anesthetist. The additional military and war hospitals scattered throughout the country are to be numbered by hundreds, and the difficulty of supplying them with skilled or even efficient anesthetists is very great. The patriotism and willingness with which medical men and women have come forward to staff these hospitals are quite above any praises of mine, but I am sure that none of them will mind my saying that the task of administering anesthetic has not always been one with which they have been most pleased or for which they have considered themselves the best fitted.

The second point is that the large number of military hospitals taken in conjunction with the frequent and necessary changes in the anesthetists who work them, renders it very desirable to standardize the equipment provided, and to render that equipment as simple as is compatible with efficiency. The standard at present is:

(1) Nitrous oxid apparatus.
(2) Schimmelbusch's frame.
(3) Clover's inhaler.
(4) Junker's bottle (Rigby's safety pattern is now issued).
(5) Tongue forceps.
(6) Mouth gag.

One or more of each is provided in accordance with the size of the hospital and the number of operating theatres in use. For special hospitals, and where special cases are treated by special anesthetists, special instruments are obtainable. To my mind the War Office is quite generous in this respect, but naturally the authorities do not wish to lend themselves to the exploitation of cranks and instrument makers.

On the whole, therefore, one is bound to select as a routine anesthetic a method which is the least liable to abuse, and in the use of which the anesthetist, even if rather below the average, is least likely to go wrong. Amid conflicting opinions the task is not so easy as it seems. There is one negative point, however, upon which I hope my opinion may be largely supported, *i. e.*, that in military surgery at home the routine use of pure, unadulterated, or as our American colleagues call it, *straight chloroform*, as a first choice is to be avoided as much as possible. Briefly stated, my chief reasons are the following:

(1) In the hands of the most skilled the mortality is relatively high. I believe that it is something approaching 1 in 2,000. In military work I do not know exactly what the proportion may be, but I will give you some figure: *Of the deaths under anesthetics which have been reported to me since January, 1917, at least 55 per cent., and probably more, were due to or occurred under chloroform used in an undiluted form, and in many other cases the chloroform was by far the predominating drug. One may admit, of course, that in many of these cases the use of chloroform was almost imperative, and that in many the condition of the patient was such, that in all probability he would have died under any other anesthetic, but such admissions do not really affect the figures. I would further point out that of that 55 per cent., in fully 28 per cent. death occurred before any operation had commenced.*

(2) In the course of my wanderings, I have been much struck by the fact that of the most earnest advocates of pure chloroform, only a comparatively small number really know how to give the drug properly. As an example of this, let me instance the gentleman whom I found pouring drachm doses of chloroform upon a lint-covered Schimmelbusch's mask, over which, and his retaining hand, he had thrown another sheet of lint about the size of a pocket handkerchief. From the same hospital I received complaint of the impurity of the chloroform which, I was told gave rise to a great deal of lividity.

Although I object to the use of undiluted chloroform as a first choice, for routine work, it must not be supposed that my condemnation extends further than this. I fully recognize the value of this drug for many cases, and I would even say that when sufficiently diluted down with ether in the shape of one or other of the mixtures and administered carefully by the open method it forms a very simple and admirable method of inducing anesthesia previous to the continuous use of ether.

For quite short cases some form of local anesthetic is, I believe, often employed, but these naturally do not come under my ken, and I have no means of knowing exactly to what extent this method is really employed. I am inclined to think, however, that it is not employed nearly to the extent that its most earnest advocates could wish, and for this I have no doubt that the surgeons could give sufficient reason.

For similar short cases an alternative is nitrous oxid. This is not used nearly so often as I should like to see it used. Two difficulties arise with regard to it. First of all the supply is somewhat scanty and irregular, and in the second place the average anesthetist in the military hospitals rather fights shy of it.

OPEN ETHERIZATION.

FAILING LOCAL DRUGS and nitrous oxid, the anesthetic of my choice for continuous work is ether, and with certain reservations and precautions I prefer the open method. The details of the particular method that I advocate do not, I expect, differ very materially from those employed by most of you, but in order to make myself quite clear, I will briefly refer to the points upon which I like to insist:

(1) A preliminary injection of morphin $\frac{1}{4}$ gr. and atropin $\frac{1}{100}$ gr. For military work I think that this should be given rather less than half an hour before the operation. In my opinion the orthodox one hour is too long. See, too, that the *patient* gets the full dose, not the bedclothes.

(2) A small pad of Gamgee tissue with a hole in it around the nose and mouth.

(3) A Schimmelbusch's mask covered with from twelve to twenty layers of gauze. This may be clipped to the pad by means of tongue forceps, and a useful hinge is thus formed.

(4) Although when time is no object and

the surgeon is good-natured, one can start with ether from the very beginning, I think that it is better in most cases partly to induce with a mixture, or even with a Clover's inhaler. In many cases I employ chlorid of ethyl on the open mask in the manner suggested by Dr. Barton.

(5) As a drop-bottle I recommend the metal flask devised by my friend, Dr. McCardie, of Birmingham. This enables one partially to regulate the flow of ether, and is therefore economical; it also possesses the great advantage of being practically unbreakable.

(6) The late Sir Frederic Hewitt introduced a very useful open airway tube passed into the mouth over the base of the tongue. I prefer to pass a smaller and softer tube about 5 inches down the nose, a device which I have found most useful, and now employ in almost every case.

This is the plan that I have advocated at most of the military hospitals which I have visited, and I believe that it is very widely adopted. The equipment of all military and war hospitals includes one or more Clover's inhalers, and at some of the hospitals I have visited I find that the anesthetist is rather wedded to that instrument and will not succumb to my blandishments in favor of the open method. Under these circumstances I generally suggest to him to try the plan proposed by Dr. McCardie of putting 1 dr. of chloroform into each 2 oz. charge of ether. I have myself had much success with this method, and believe it to be capable of extension in various directions, for instance, I am inclined to think that the same degree of dilution might be used by the open method all through, and would to some extent meet the objection so often raised as to the large quantity of ether required in long cases. In this connection I may perhaps say that from a large number of figures I have obtained I estimate that the quantity of ether required for open administration works out at 6 to 8 oz. per hour (in Malta it was to 8 to 10 oz.). Whichever plan has been adopted, I am very certain that less pure chloroform and more ether is being given in the home hospitals now than was the case twelve months ago. I think, too, that I can point to some definitely good results which have followed the change, for the death rate for the quarter ending September 30 has been rather less than one-half of the average rate for the two quarters preceding.

ANESTHESIA FOR SPECIAL CASES.

I NOW COME TO THE question of the anesthetic to be used in the various special cases to which I have alluded. *In the cases of modified or chronic shock to which I have referred I doubt whether one can give too much morphin, but in cases of sepsis, malaria and other heart trouble, I would avoid the use of morphin.* In other respects I would base my anesthetic treatment of all these cases upon three fundamental lines, *viz.:*

(1) Avoid all but the most dilute doses of chloroform.

(2) Give as little anesthetic of any sort as possible.

(3) Avoid anything like asphyxia, by diluting the vapor very freely, for which purpose oxygen given either by itself or bubbled through your anesthetizing agent is very useful.

It is in such cases as these that the use of the continuous gas and oxygen methods of the American surgeons seems likely to be of considerable value. Others who are contributing to the Year-Book will write more in detail as to the particular advantages of this method. All I will say at present about it is that the present forms of apparatus seem to me to militate considerably against its general employment, nor am I quite convinced as to the quality of the anesthesia produced.

In discussing the question of a routine anesthetic I purposely avoided any allusion to the warm ether method, mainly because Dr. Shipway will probably write upon that method, but partly because it does not appear to be used to any great extent at home, partly, also, because the method seems to me to lack that element of simplicity which I believe to be so essential when dealing with a large number of administrators of varying skill and capacity. I think, however, that in the class of cases with which I am now dealing, *i. e.*, chronic shock and sepsis, warm ether would very likely be of considerable advantage. *In intracranial cases, morphin is usually unnecessary, as the patient is often in a semi-comatose or dazed condition. For the same reason, too, very little anesthetic is required. In these cases I prefer chloroform because it is desirable to limit the venous congestion as much as possible. I usually administer it by means of a Junker's bottle, through which I pass a very small stream of oxygen, leading the mixture of chloroform vapor and oxygen down the nose by means of a soft tube.*

The mortality arising from operations of the empyema type is rather heavy. Most of the cases dealt with in the home hospitals are of course of the chronic type, and have been the subject of prolonged and severe suppuration. They are, therefore, particularly bad subjects for anesthetics of any sort. There is no doubt that these cases ought all to have some form of artificial respiration as is typified in the intratracheal method. Unfortunately, however, my experience is that neither the anesthetist nor the surgeon seems always to grasp the seriousness of the problem which is before them when they decide to operate. The intratracheal apparatus is so cumbersome, costly, and difficult to manipulate that but very few establishments are equipped with it. Not only so, but the anesthetists are constantly changing, so that even when one man has learned to use it the probabilities are that he gives place to another in the course of a few weeks who does not know how to use the machine. I can only think that these cases ought to be concentrated in a few of the better equipped hospitals where this method is available. Failing this, chloroform and oxygen should be given very gently from a Junker throughout the operation.

In cases of spinal injury the position is often complicated by the fact that the patient is turned wholly or partly upon his face; this not only entails compression of the chest but obliges one to pump the anesthetic into him. Then again, avoidance of venous congestion is desirable. Taking all these points into consideration I am inclined to give these patients oxygen and mixture from a Junker's bottle. But these are cases in which the care and vigilance of the anesthetist are more important than the actual method employed.

One would imagine that orthopedic surgery was the special field for the use of the intraspinal methods, but I am surprised to find that, as far as my experience goes, this is not the case; nor is any explanation forthcoming. Nitrous oxid is frequently used, and it requires a good deal of skill in the manipulation of the administration to hit off the precise moment at which the fullest possible degree of relaxation is obtainable. The average orthopedic case does well enough with ether, but it must be ether given without a trace of asphyxia so that there is as little congestion of the veins as possible. At one of the orthopedic hospitals visited I received complaints about the amount of venous congestion, which in this instance was attributed to the use of warm ether, and unless the warmth of the ether vapor is very carefully regulated it does seem to produce considerable venous congestion.

ANESTHESIA FOR PLASTIC FACE SURGERY.

THE QUESTION OF THE anesthetic in plastic face surgery and allied conditions deserves a whole chapter to itself. It is one in which I have taken a great deal of personal interest, and one of the most difficult questions with which we have to deal. *The chief troubles arise partly from the presence of large quantities of blood in the mouth and pharynx, partly from the necessity of getting out of the way of the operator, and partly also from the difficulty in manipulating the anesthetic when the jaw is wholly or partly fixed, or even perhaps unduly mobile. There is no operation in which the anesthetist can be of so much real assistance to the surgean, or where the value of a good anesthetic is so conspicuous.* For this reason I do not favor the view sometimes taken that one particular method should alone be employed. Not only do the cases vary very much in themselves, but one should take into account the capabilities of the anesthetist. In some few instances the ordinary routine methods are possible, but these are rather in the minority. In most cases exceptional methods will have to be employed. Of these exceptional methods I recognize four varieties:

(1) *The intratracheal method.* I place this first on the list, for just now it is very much in fashion. I acknowledge that in some cases it is almost indispensable, but I do *not* admit that it is necessary or even advisable in all or even in the majority of cases.

(2) Allied to this plan is what I would call *the intubation method,* by the means of a Kühn's tube. This method is little known in this country and I believe that it has many advantages, for the whole of the pharynx can be fully packed and the blood and mucus are then absorbed.

(3) Another plan which I also think is not as much practiced as it should be, is the *colonic ether-oil method of Gwathmey.* I have used it myself many times and seen it used by others, and always with satisfaction and advantage. It is probably the simplest known method of giving an anesthetic.

(4) The fourth plan—*the method of position*—is one I naturally esteem highly, as I am mainly responsible for its use in this type of case; but for that very reason I am not disposed to say much about it now. Anesthesia is induced with the patient sitting bolt upright on the table, any routine plan being adopted. The anesthesia is maintained by means of a nose-tube conveying oxygen and chloroform vapor; or the vapor of mixture or ether may be used. This plan has been sharply criticized, but at least I can say of it that it has been in use now for over a year at one of the principal "facial" hospitals in the kingdom, and that no fatalities have attended its use.

Whichever plan be employed, it may be supplemented by the use of some form of suction apparatus on the principle of similar tubes used by dental surgeons and with the same object, *viz.,* the removal of blood and mucus from the buccal cavity.

ETHER BRONCHITIS RECORDS.

BEFORE CONCLUDING WHAT I have to say on the methods of anesthetization there are, however, two minor points to which I should like to draw your attention. The first of these is the occurrence of the so-called *ether bronchitis.* In the pre-war days one was very much inclined to put this down off-hand to simple exposure, either in draughty passages or in the wards themselves. In my visits to hospitals of very varied type throughout the country, however, I have come across cases of bronchitis under such different conditions and surroundings that I am not at all sure that the theory of *exposure* will hold good. In some places it almost appears to be epidemic; in others it partakes of the nature of an epidemic; while in other places again where it ought to be rampant it hardly ever occurs. The second point is the question of records. In the original army scheme the only provision made for recording the work of the anesthetist was in the shape of one, or at most two rather narrow columns in the *operation book.* In Malta I drew up a form for this purpose, and from it I obtained some valuable information, the hospitals being all within reach and the operations not over numerous. A somewhat similar form is now in use too, in most of the English Commands. Though I am not satisfied with the results; the figures do not appear so reliable. But at any rate I think that they have served one useful purpose, *viz.,* that of increasing the interest of the men in their anesthetic work, something that is very desirable.

ANESTHETISTS AT THE FRONT did not have the same opportunity accorded those at home of using nitrous oxid-oxygen anesthesia extensively. It is fortunate that H. E. G. Boyle, of London, England, was so situated as to be able to have made such an interesting and instructive study of nitrous oxid-oxygen anesthesia *with rebreathing* in military surgery, which he published in the Lancet, November 3, 1917, and which is herewith reprinted for the benefit of those who are especially interested in the value and possibilities of rebreathing.

GENERAL CONSIDERATIONS—PRE-MEDICATION AND APPARATUS.

THE ANESTHESIA PRODUCED by the combination of nitrous oxid and oxygen with rebreathing, and ether, or chloroform and ether when necessary, is one that should appeal to anyone who has the interests and welfare of his patients at heart. The easy induction, the rapid and comfortable recovery are factors that all men who are interested in anesthesia will at once appreciate.

The anesthesia and the technic that I shall attempt to describe are what I have been using at the First London General Hospital. To begin with, the patients are given a preliminary injection of morphin, atropin, and scopolamin about half an hour before the time of operation. I think that half an hour is sufficient to enable one to get the full value of the injection during the anesthesia. Of course, it is not always possible to be sure that half an hour has elapsed before starting the anesthesia, for it is obvious that in a busy morning of 12 to 15 cases it is at times difficult for the sisters to estimate correctly the exact time at which any one case will get to the theatre. I know that I have anesthetized patients who had only just had the injection and patients who had had it an hour or more beforehand. The proportions of the injection that I use are: Morphin tartrate, $\frac{1}{6}$ gr.; atropin sulphate, $\frac{1}{120}$ gr.; scopolamin, $\frac{1}{100}$ gr. This is made up so that 5 minims is the dose.

The apparatus that I use is Gwathmey's, and consists of four cylinders, two N_2O and two O. The supply of N_2O and O is controlled by means of two graduated taps, which permit the gases to flow through the glass bottle containing water in a proportion that can be seen, so that one has visual evidence of how much of each gas is being inhaled by the patient. The gases may go direct to the patient *via* the rebreathing bag, or may be directed through the bottle containing either ether or chloroform and ether, or such mixture as the administrator chooses to place there. The face-piece has at its top a valve to permit a certain amount of intake and output of air and mixed gases, but in actual practice one does not use this valve a great deal except for those patients who will not stand prolonged rebreathing on account of attempts at vomiting during the anesthesia.

TECHNIC OF ADMINISTRATION.

ONE OF THE most important factors in the production of good anesthesia is that during the induction the room should be absolutely quiet. This condition, great as I know the importance of it to be, is well-nigh impossible at a base hospital, as those of us who work there well know, but it can be ensured even there, and in private practice we ought to insist on it.

Position.—Gwathmey lays great stress on the importance of having the patient absolutely flat, without even a small pillow, alleging that he finds that breathing is better. My own experience leads me to think that patients as a rule do not like their heads quite so low, and my usual practice is to have the head slightly raised during the induction, and when anesthesia is complete I gently lower the head to the horizontal.

Dental Prop.—I frequently insert a small dental prop between the teeth before starting the anesthesia. The point to be careful about is to observe whether the patient breathes easily through the nose, and if he does not, or if the nose is a narrow one, with very thin alæ nasi, then I always insert a prop. I have found that patients who have these thin alæ nasi will give trouble unless a prop is inserted. The alæ are drawn in towards the septum and the patient makes violent efforts to breathe, but gets nothing or next to nothing into his lungs. When this happens the patient becomes pale, with a bluish tint around the mouth, the pupils dilate, and sweating comes on. Treatment for this condition is to open the mouth and get air and oxygen into the lungs.

ADMINISTRATION.

THE BAG IS three-parts filled with N_2O and O in the proportion of 4 to 1, that is to say, oxygen is allowed to bubble through one hole and nitrous oxid through four. The face-piece is adjusted to the face and the gas-valve turned on. And here, let me say, that the face-piece must fit accurately. If air is allowed to get in at the sides the even course of the anesthesia will be greatly hampered and there will be a period of excitement and struggling. The valve at the top of the face-piece is kept open for a few breaths and then turned off, so that rebreathing starts almost from the beginning. The supply of nitrous oxid is now increased until it is flowing in freely through all the apertures and even through the tube itself. I do this to lessen the period of induction, for I hold strongly that the period of induction ought always to be as short as possible —seeing that it is the most unpleasant. In a very short time the patient's breathing grows deeper and more regular until eventually in about three to four minutes it takes on that *automatic rhythm* which is such a constant sign of anesthesia.

It is necessary to keep a strict watch on the patient's color, and any degree of cyanosis must at once be remedied by the addition of a little oxygen. It is remarkable how readily these patients respond to oxygen, so much so that only a very little is needed to change the color back to pink. In my early cases I did not realize this fully and gave oxygen until the pink color returned, and in consequence in a few cases I very nearly brought my patient out of the anesthetic state. I now find that it only needs a short, sharp turn of the oxygen valve which opens three or four holes for about two seconds.

As soon as anesthesia has been attained the amount of nitrous oxid coming over is reduced to 4, the oxygen being at 1. With this rate most patients will go on perfectly well and rebreathing can be continued most of the time. If, however, the patient begins to retch or vomit then I think that there is too much rebreathing and one opens the valve on the face-piece and increases the supply of both oxygen and nitrous oxid.

If it is required to deepen the anesthesia the pressure in the bag must be increased until when an expiration takes place the bag becomes taut. This will deepen the anesthesia in a few seconds, but the patient needs careful watching lest he get blue.

Page prefers to give ether to deepen the anesthesia rather than to push the N_2O under pressure, and on the whole I agree with him.

The signs of overdosage are first of all noisy and stertorous breathing, followed by twitchings of the muscles and accompanied by cyanosis. None of these signs ought to occur in a well-given anesthetic. The remedy, of course, is more oxygen.

The aim of the administrator should be to get an even anesthesia, and this is best obtained by being quite sure that the true state of anesthesia is present before the operator starts, and the keeping the supply of gases at as constant a level as is possible. *Anxious movements of the supply taps only lead to bad anesthesia.* In this, as with other methods of anesthesia, the importance of the open and free airway must never be forgotten.

Mixtures.—It sometimes becomes necessary to add either ether or C.E. mixture to the gas and oxygen in cases where extra relaxation of the muscles is required, or during amputations, when the nerves are being severed. And here, let me say, that I have observed that when large nerves are cut in nearly every case the patient moved unless he was being given ether or C.E. This movement does not appear to do any harm, but is troublesome for the operator. Occasionally, if one is having a little difficulty during the induction in obtaining anesthesia, I find that the addition of ether for a few seconds is frequently enough to produce the required state, but one must be careful not to keep the ether on for long, as this causes coughing and holding of the breath. Just turn it on and off, the whole movement taking about two seconds, and repeat this at intervals of one to two minutes until anesthesia is complete. I have seldom found it necessary to give ether or mixture continuously for long—three to four minutes being probably as long as it is ever necessary.

I am not at present prepared to make any definite statement as to the relative values of ether or chloroform and ether with this method, and have up to the present only added chloroform when I have come across some especially burly or alcoholic patient who needed something more potent than ether alone. I find on going through my cases that 38 per cent. have had ether or chloroform and ether.

Rebreathing.—Those of us who were in the habit of giving prolonged nitrous oxid and oxygen with a Hewitt's apparatus know that it was a wasteful method—wasteful of the gases, but, what is more important still, wasteful of the patients' energies. A long nitrous oxid and oxygen without rebreathing frequently left the patients in a very exhausted state. They often had profuse sweatings, and in a good many instances patients were far from well for some hours afterwards. With regulated rebreathing, however, this is not the case. The patients keep a good color and their temperature is, if anything, slightly raised, and there should be no sweating. The temperature of the expired air as felt when the valve at the top of the face-piece is opened is warm to the hand. I have not thought it of sufficient importance to have this air analyzed or to record its temperature.

Overdose.—The treatment for overdose is rapidly to remove the mask and start artificial respiration together with the administration of oxygen, remembering always to keep the airway clear.

POSTOPERATIVE CONDITION.

THE POSTOPERATIVE condition of patients who have been anesthetized with nitrous oxid and oxygen with rebreathing and with a little ether when necessary, is to me one of the most striking points of the method. The patients are conscious within two or three minutes of the removal of the anesthetic, and in the majority of cases are not sick. At the First London General Hospital I have had records kept of consecutive cases, and the result is that of 200 consecutive cases 13 were sick once, 4 twice, and 3 had prolonged sickness (*i. e.*, 2 most of the night and 1 for 2 days).

There is in a fair proportion of cases a feeling of nausea which lasts for about 20 minutes, and occasionally there is some headache, which is probably due to too much rebreathing for the particular patient, but beyond that the recovery is perfect. There is no horrible taste of ether in the mouth, no waves of ether vapor coming over as the patient eliminates the drug. And this holds good, even if a little ether has been given during the early stages of the anesthetic.

One of my most striking cases was an officer who had had the semilunar cartilage removed. The operation lasted about 40 minutes and finished at 5.30 P. M. At 7.30 P. M. he enjoyed a full dinner, a result that I think is unobtainable with the older methods.

Since both of the gases are non-toxic it follows that this combination is especially suited to those cases of which we have all seen such a number—the badly wounded and septic man. These cases do particularly well, and at the First London General Hospital we have records of three cases of amputation at the hip in men who were profoundly septic and who have all done splendidly.

I wish that I were possessed of sufficient power of oratory to paint you a real word-picture of the after-condition of the patients, but, alas, I am unable to do it justice. For a proper appreciation of the condition one should see the operation and the patients afterwards. There is one point, however, that I should like to bring before you as a result of my analysis of 200 consecutive cases at the First London General Hospital. It is that I observe that in most of the cases there is no appreciable rise in temperature after the operation. We are most of us familiar with the rise of temperature as shown on the temperature charts after an operation. This does not appear to be the case after an administration with this combination.

At Queen Alexandra's Hospital for Officers at Highgate, where I have used this method extensively, Mr. H. J. Paterson—who is in charge of the hospital—has observed and commented on the fact that there is no rise in temperature after this anesthetic. The temperature remains steady when clean cases are being dealt with, and even in septic ones I find that the rise is not as great as with other anesthetics.

SUMMARY OF CASES.

Administered by H. E. G. Boyle	550
Administered by J. F. Trewby and residents at First London General Hospital	161
Total	711

Of these, 5 have had bronchitis, and 1 of these 5 has had slight bronchopneumonia.

Of the 550 cases administered by H. E. G. B., 38 per cent. have had either ether or C.E. mixture (2 have had $CHCl_3$ alone).

Fatal cases, nil.

	During	After		
Vomiting	1	20	Once	13
			Twice	4
			Bad vomiting; 2 most of the night, 1 for 2 days	3

Thus only 15% had what could be termed "bad" vomiting.

Temperature.—Highest rise, 101°-105° (drainage of buttock). Average rise, 0.9 of a degree. Three men complained of pain (all of them were bone cases). Two men said that they preferred to come round 2-3 hours after operation. One appendix—$CHCl_3$ added for relaxation, but this was not good. One hemorrhoids—C.E. added, but was difficult to keep quiet. One amputation above ankle required 1 ounce of ether. (This is the largest amount of ether that any of the 200 cases have had.)

Nursing Care.—The work of the nurses is considerably lessened when this combination is employed, for it is obvious that if on the return to the ward the patient is conscious and not vomiting he does not need the undivided attention of a skilled nurse. And this point is of extreme importance in a large military hospital, since it often happens that 8 or 10 operations may be all from the same ward during a morning's work. The contrast between 8 to 10 semiconscious and probably vomiting patients and 8 to 10 men who are conscious and not sick is one that appeals greatly to an overworked nursing staff.

I have been at some pains to discover the opinion of the sisters and nurses with regard to their patients after this anesthetic, and from inquiries which I have made at the various private hospitals for officers to which I am attached, as well as at St. Bartholomew's and the First London General Hospital, the consensus of opinion is that they much prefer to have their patients given gas and oxygen to anything else.

CONCLUSION.

IN CONCLUSION LET ME SAY that my reasons for bringing this matter forward are because I am quite convinced that it is an advance on the older methods of anesthesia and, from the patient's point of view, it is infinitely a better form of anesthetic than ether or chloroform, for after this combination the recovery in the great majority of cases is devoid of those unpleasant and distressing conditions with which most of you are familiar.

This paper, then, may be taken as an attempt to procure a more extended use of gas and oxygen with regulated rebreathing in major surgical procedures, and especially in the treatment of our wounded.

My own experience of this method with our wounded men has been confined to work at the First London General Hospital and to various hospitals for officers in London, and I unhesitatingly say that in my opinion the combination of anesthetics which I have attempted to describe is infinitely better for most of the men than ether, chloroform or mixtures thereof. Of conditions at the front I cannot speak with such certainty, as I have, unfortunately, not been there, but it appears to me that it would be of considerable advantage out there if after most of the operations the patients were conscious within a few minutes. It would lessen the work of the orderlies and nurses, and, apart from this aspect of the matter, we must remember that this anesthetic is non-toxic, and therefore there is less strain put on the patient, seeing that he does not have to eliminate the drug, be it ether or chloroform, from his system. Moreover, there is no shock after gas and oxygen.

Finally, let me give one word of warning. This combination of anesthetics is not one to place in the hands of the careless or inexpert—it requires skillful administration and if used carelessly will inevitably lead to disasters.

AS PATIENTS COMING to operation under anesthesia in home military hospitals, soldiers present several types that are best handled under certain selective methods of anesthesia. After a considerable experience along these lines, Thomas Clarke, of London, England, writing in the British Medical Journal, January 19, 1918, reports on his selective methods as follows:

Having now been administering anesthetics for several years in hospital and private practice and daily for the last seven months at the Lord Derby War Hospital, Warrington, with 3,000 beds in the summer and 2,500 in winter, the following is my experience:

The patient is given as a preliminary morphin $\frac{1}{4}$ grain, atropin $\frac{1}{150}$ grain, half an hour before the operation. The preliminary injection of morphin and atropin is not only followed by less secretion of mucus and a quieter anesthesia, but the patient usually sleeps for an hour or two after the operation, thus causing very much less trouble to the nursing staff—a great advantage in a busy hospital.

ANESTHETICS USED AND TECHNIC OF ADMINISTRATION.

THE ANESTHETIC MOSTLY used by me is ether, preceded by chloroform. I use two separate masks, one covered with a layer of lint for chloroform and the other with two layers of lint for ether. By using two separate masks the danger of giving a mixture of unknown strength is avoided, and I almost invariably use the open ether drop method on a Schimmelbusch mask.

At the beginning of the administration I drop about one drachm of chloroform slowly on the mask, holding it an inch or so from the patient's face and quietly talking to him, or in nervous cases getting him to count. During this time the mask is lowered, until in about a minute or so it is resting on the face. I then replace it by the ether mask and quickly drop on ether till the lint is saturated. Next I place a towel, two or three folds over the mask to increase the concentration, leaving sufficient space to apply the anesthetic continuously. By this method I rarely get any struggling and often not the slightest movement on the part of the patient, who is generally ready for the operator in three or four minutes. This ensures the maximum degree of safety is certainly very quick, and preferable to beginning with ether alone. Patients all agree that the chloroform is pleasanter and less irritating. For instance, it is quite the rule for those men who have had both anesthetics to tell me that they prefer chloroform. The average quantity of anesthetic for an operation of half an hour is 2 drachms of chloroform, 3 oz. of ether. Occasionally it is very difficult to keep some of these young subjects under with the ether drop method alone, especially in abdominal cases, and it may be necessary to resort to a little chloroform or C.E. mixture for a short time and then resume the ether.

VALUE OF OTHER METHODS.

IN MY PRIVATE and previous hospital experience I have administered nearly three thousand anesthetics, the bulk by the method outlined, and have not had one fatal case or any serious difficulty.

In my early days I was taught to give ether by the Clover method, but now rarely use it, for to my mind the ether drop method is very much better, in that the patients very rarely get cyanosed, have less trouble with mucus, a quieter anesthesia, and less sickness after the operation.

I have also introduced a Shipway's warm ether apparatus, and, in conjunction with my own methods, find it very useful in cases requiring prolonged administration, in that it conserves the body heat of the patient, and is also a saving of the anesthetic.

Ethyl chlorid and nitrous oxid have proved quite satisfactory for patients requiring a short anesthesia such as for incisions and manipulation of joints.

PECULIARITIES OF ANESTHESIA IN MILITARY HOSPITALS.

I FIND AFTER GIVING anesthetics daily in a military hospital, that it is quite different from administering them in a general hospital in peace. In the latter it is the exception to have a strong, healthy young man to anesthetize, the majority of cases being women and children or men usually with a definite organic or inflammatory lesion and often well prepared for an operation. Military cases are frequently robust young men who have lived an outdoor life for varying periods and many of them have been in the trenches and subject to war strain and nervous exhaustion. *I have also found that men suffering from shell shock require much more anesthetic than other men and have a greater tendency to excitement while going under. In these cases a little encouraging suggestion during the first stage of anesthesia not only helps during the administration, but is also beneficial afterwards.* At first I was inclined to attribute this to the mode of living, which made them difficult to anesthetize, but I am now convinced there is a nervous element to contend with. It is impossible in many cases to judge by the appearance of the men how they are likely to behave under an anesthetic. Some of the apparently quiet and sickly-looking men take a large quantity of anesthetic and become troublesome with excitement, whereas some of the rough-looking and vigorous need very little.

GETTING TO THE TOP IS A HARD, PAINFUL JOB AND A MAN NEEDS EVERY HELP HE CAN GET; ABOVE ALL, THE ACTIVE SYMPATHETIC INTEREST OF THOSE AROUND HIM; A CLEAR VISION TO HELP HIM MISS SOME OF THE FALSE STEPS; AN ABUNDANCE OF WARM ENTHUSIASMS AND A LASTING APPRECIATION OF THINGS THAT COUNT. ALL THESE MAKE IT NECESSARY FOR HIM TO HAVE A SORT OF UNIVERSAL SYMPATHY, WHICH WILL GIVE HIM DIRECTNESS AND SIMPLICITY. HE IS NEVER FENCED IN WITH TORTUOUS MANNERS; NOR IS HIS VIEW OBSCURED BY CIRCUMLOCUTION OF PHRASES. HE MEETS MEN AND IDEAS AND CIRCUMSTANCES FACE TO FACE—SMILES IF THEY ARE FRIENDLY, AND SETS HIS JAW IF THEY ARE NOT. BUT, WHETHER FRIEND OR FOE, HE MAKES NO ASSUMPTION OF ARROGANT SUPERIORITY. IT IS MERELY A MATTER OF MAN TO MAN. HIS WORK, HIS ENVIRONMENT, HIS HEALTH MAY MODIFY THE CUSTOMS AND HABITS OF THE MAN AT THE TOP; BUT INVARIABLY HE IS AT HEART THE SIMPLEST, FRIENDLIEST, MOST APPROACHABLE, OPEN-MINDED, DIRECT MAN YOU CAN MEET. FOR THIS IS THE MANNER OF MAN WHO GETS TO THE TOP.

—*William H. Hamby.*

ETHYL CHLORID-CHLOROFORM-ETHER ANESTHESIA FOR RAPID INDUCTION AND MINOR SURGERY IN WAR . MIXTURE . HOOD OR MASK . METHOD OF APPLICATION . ACTION OF THE MIXTURE . THE PATIENT'S RESPONSE . ANESTHETIC POINTERS . FURTHER CONSIDERATIONS . SCHLEICH'S MIXTURE IN WAR SURGERY FOR RAPID ANESTHESIA . APPARATUS . ANESTHESIA . AN ETHYL CHLORID-ETHER VAPOR SEQUENCE FOR ANESTHETIZING SOLDIERS . TWO TYPES OF SOLDIER PATIENTS . CONTRAINDICATIONS TO CERTAIN ANESTHETICS AND MIXTURES . ADVANTAGES OF THE ETHYL CHLORID-ETHER SEQUENCE . THE APPARATUS USED . PRECAUTIONS .

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THE RAPID INDUCTION of anesthesia as well as rapid anesthesia for minor surgery were two of the big problems in war surgery. Various mixtures and sequences were used for both purposes. As instructor in anesthesia at a number of A. E. F hospitals in the Vittel medical center, France, Arthur E. Guedel, of Indianapolis, Ind., developed the following modification of the DePage mixture for successful use in thousands of inductions and rapid anesthesias. Guedel gives the following account of his experiences:

The following is an E-C-E Sequence (ethyl chlorid, chloroform, ether), by the closed method. The idea is taken from the DePage mixture used in the French clinics, but the formula has been modified. It is of value for the rapid induction of all ether anesthesia and is of especial value as an anesthetic for short operations and the dressing of painful wounds. From the initial application a period of operative anesthesia, lasting from 12 to 20 minutes is obtained. Induction for operation is completed in about 2 minutes.

This report is based upon observations of about 2,000 anesthesias.

MIXTURE.

THE MODIFIED FORMULA of the mixture is as follows:

One dose

Ether	24 cc.
Chloroform	½ cc.
Ethyl chlorid	5½ cc.
Oil of orange	⅛ cc.

While the oil of orange is not essential, it serves to render the application of the mixture more pleasant to the patient and this consideration is appreciated. It has been our custom to make up this mixture in four ounce quantities, thus:

Four ounce mixture

Ether	96 cc.
Chloroform	2 cc.
Ethyl chlorid	22 cc.
Oil of orange	½ cc.

One ounce of this mixture is the usual dose. Debilitated soldiers required the administration of but ¾ of an ounce, while an occasional robust subject needed 1¼ ounces.

This mixture is stable for 3 or 4 days if kept tightly corked. Care must be used in its mixing and handling as the extreme volatility of the ethyl chlorid causes it to leave the mixture very readily. It should be stored in a cool place.

HOOD OR MASK.

THE HOOD, USED for the administration of this mixture, was made as follows: A circle of rubber sheeting was cut to the diameter of 20 to 22 inches. An elastic, purse-string was strung through the faced edge of this circle. This elastic was approximately 15 inches long. The general effect on completion was that of a large bathing or dusting cap. A ventilating hole ½ inch in diameter was cut in the center of the hood. In this hood was placed a gauze-covered cotton pad about ½ inch thick and some 6 to 8 inches square.

Fig. 1. The Mask and the Bottle of the Mixture.

METHOD OF APPLICATION.

WITH THE COTTON PAD resting flat in the upturned hood, one ounce of the mixture is poured at once over the pad and the hood is immediately placed over the patient's face, the elastic purse-string stretching around the crown of the head and encircling the chin. This allows the saturated pad to fall close to the face of the patient. It should be lifted up immediately by being grasped through the rubber sheeting and held away a slight distance to lessen the pungency of the concentrated vapor.

ACTION OF THE MIXTURE.

THE ACTION OF THE mixture must now be remembered. The ethyl chlorid will first leave the uplifted pad, filling the space within the hood with its vapor. This is sufficiently potent to produce complete ethyl chlorid narcosis. As the ether vapor will not leave the uplifted pad in sufficient concentration to produce ether anesthesia before the effects of the ethyl chlorid have vanished, the pad is lowered so that the mixture is directly over the nose and mouth of the patient, forcing the patient to breathe through the saturated area, thereby drawing out the ether vapor in sufficient concentration and quantity to produce ether anesthesia before the patient emerges from the ethyl chlorid narcosis. The hood is left in this position throughout the induction or operation, the jaw of the patient being supported, if necessary.

Although there is very little chloroform in the mixture, its presence is sufficient to prolong the ethyl chlorid effect until the ether has had time to act fully. Results with ethyl chlorid-ether mixtures without chloroform were not satisfactory and the mixture, herewith presented, contains the smallest quantity of chloroform commensurate with good results.

THE PATIENT'S RESPONSE.

THE PATIENT, at first, is apt to be frightened by the procedure, but not to any great extent. If he be directed to take *short* breaths he will experience no unpleasantness during the brief interval before unconsciousness supervenes. If his first breath is a long one the pungency of the mixture will be slightly disagreeable. The average stage of excitement is far shorter than that occurring with straight etherization. After a patient has once been anesthetized with the mixture there is no excitement stage during other administrations. Some patients have taken this form of anesthesia on as many as 15 consecutive days for painful dressings, without untoward effect. In most instances patients have insisted upon having this anesthesia for the subsequent dressings of their painful wounds.

(*Courtesy of Dr. E. P. Quain.*)
Fig. 2. The Mask Applied to the Patient.

Any effects, aside from those directly traceable to etherization itself, have been negligible. Patients, who had eaten within an hour preceding anesthesia, would frequently vomit.

ANESTHETIC POINTERS.

IN THE APPLICATION of this rapid induction method of anesthesia for military surgery, it is the action of the ethyl chlorid content of the mixture that must be understood.

Ethyl chlorid, in overdose, produces either (a) pharyngolaryngeal spasm, which if the overdose be continued will proceed to respiratory obstruction or (b) a slower depression of respiration from the anesthetic effect on the central nervous system. Crowing inspiration is the warning of pharyngolaryngeal spasm, and fortunately its onset is gradual. The hood need not be removed at the earliest manifestations of this spasm as it often occurs with this method with the given dose of ethyl chlorid, but is of slight intensity. The patient showing such spasm *after consciousness is lost* should be watched and the hood removed if the spasm grows progressively deeper. The spasm, sometimes seen before consciousness is lost, is due to the pungency of the vapor, when the pad has not lifted from the face quickly enough. It is of no consequence. The true ethyl chlorid spasm occurs only from overdose and is never manifested until after consciousness has been lost.

In this recorded series of some 2,000 administrations it was deemed necessary to remove the hood, on account of spasm, only on three occasions. In these three instances anesthesia was continued with straight ether.

Progressive depression of respiration, from the central effect of the anesthetic, is easily detected because of its progressive character and there is ample time for the removal of the hood and withdrawal of the anesthetic mixture before respiration ceases altogether. Respiration will cease most certainly if the overdose is continued. But as ethyl chlorid seems to have no effect on the cardiovascular system, even though depression should go on to complete cessation of respiration, there is no need for alarm. The condition may be likened to respiratory paralysis under ether, except that it is much less serious and can be more easily handled. Ethyl chlorid is so rapidly eliminated that from one to five movements of artificial respiration serve to carry the overdose away from the medulla and reestablish normal breathing.

In the 2,000 recorded administrations of this mixture it was deemed necessary to remove the hood and withdraw the anesthetic in two instances because of this depression of respiration. On no occasion did respiration cease completely. In my own experience I have not observed that spasm and depression occur in the same individual. Apparently they are different reactions and just why one patient should show spasm as a result of overdose and another respiratory depression, is still inexplicable. However the fact remains. Also in my own observation one case of depression was noted to every ten cases of spasm. This ratio of untoward symptoms held good for the entire series.

These observations on the action of ethyl chlorid are based, not on the method of mixed induction anesthesia, as herewith described, but on studies of ethyl chlorid, *per se*, as a general anesthetic. The untoward symptoms are included, not because these symptoms are frequently noticed during induction, but simply to counteract the faulty impressions generally prevalent regarding the dangers of ethyl chlorid, due to lack of acquaintance with its action and effect. It is in no wise so treacherous nor toxic as chloroform. (See this Year-Book.)

FURTHER CONSIDERATIONS.

AS ALREADY STATED the anesthesia with this method is induced in the average time of 2 minutes or less and the initial application affords an available period of from 12 to 20 minutes of operative anesthesia.

In some cases the ventilator opening in the top of the hood is insufficient to prevent the cyanosis of rebreathing, in which instances the edge of the hood is lifted, from time to time, from the face to admit fresh air. Cyanosis is not at all necessary to the success of the method nor is it to be tolerated.

This method is a great time saver in inducing other anesthesia either by the open-drop or semi-closed method of administration. Two minutes after the hood is supplied the operation may be started. The hood is preferably removed in from 6 to 8 minutes for the change to straight ether. At this time the narcosis from the rapid induction mixture is deepest.

It is necessary to watch the patient closely for the first 3 minutes following the application of the hood, as it is during this period that the ethyl chlorid in the mixture is active. After 3 minutes the effect of this agent is negligible and the patient is practically subject only to straight ether anesthesia by the closed method.

If the pad is not raised immediately after the hood is applied, there will be some breath holding, and if the patient takes a long, deep breath at first, even if the pad has been raised, breath holding may also result.

If the pad is not lowered to the face as soon as the ethyl chlorid narcosis supervenes bringing a concentrated ether vapor into effect, the potency of the ethyl chlorid may vanish while the patient is in the excitement stage of etherization, in which case there may be some resistance and struggling.

Owing to the exigencies of circumstances the anesthesias upon which this report is based, were given in the rush of war surgery, during periods of intense activity, mostly by nurses and hospital orderlies, who had had no previous training in anesthesia. They were working under my direct supervision.

P. PICARD, of Paris, France, a surgeon in the French army, was also placed in a position to try out the utility of rapid anesthesia in war surgery. He not only found the typical Schleich's mixture very serviceable but also modified Noiré's ethyl chlorid mask for its use. The following is an account of his method including a description of his apparatus:

This procedure, inspired by that of our preceptor, M. Savariaud (La Presse Medicale, No. 55, 1917), has rendered us the greatest service during the most intense activity of our Unit. Since January, 1917, we have employed it exclusively for all our general anesthesias.

Simplicity and rapidity of anesthesia, without complicated apparatus so difficult to procure, are of great importance from the standpoint of surgical service. It is on this account that we recommend this simple, convenient and easily-constructed apparatus.

APPARATUS.

IT IS SIMILAR TO but larger than that of our comrade Dr. Noiré, employed for prolonged, general anesthesia with ethyl chlorid. The mask is a truncated cone of galvanized metal 12 cm. high. The bottom is modeled to accurately fit the nose, cheeks and chin. To accomplish this it is reinforced with a thickened border. The top is closed by a cover which can easily be removed. The inside of the mask is divided, by a metal-mesh partition, into compartments of about equal size. The upper compartment is the reservoir for the anesthetic. Near the top and to the left it is connected with a rebreathing bag (as in the Ombrédanne and Camus inhalers), so that the respiration may be partially or entirely confined. Symmetrically and to the

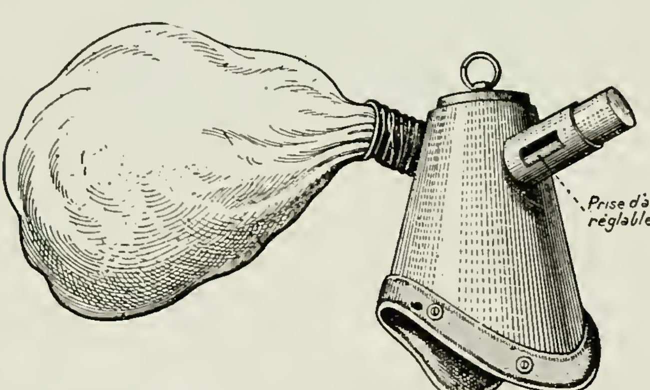

Fig. 1.

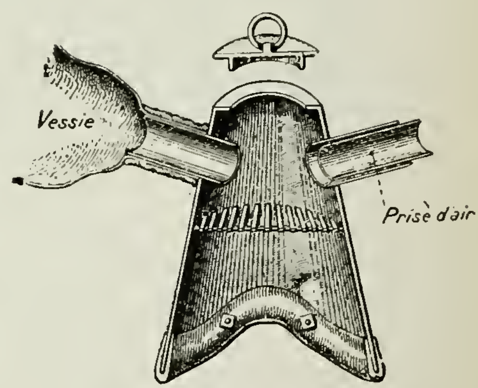

Fig. 2.

right is an air-vent, easily regulated, formed by two sleeved tubes, with overlapping openings 2 cm. by 0.007 mm.

ANESTHESIA.

THE CHOICE OF THE anesthetic is not indifferent. We employ exclusively Schleich's mixture (ether 60 grams, chloroform 20 grams and ethyl chlorid 10 grams), which is easily made. For a long time J. Louis Faure has drawn attention to this mixture. Upon the anesthetic table is a graduated glass and flask of Schleich mixture, prepared in advance. When everything is in readiness for the operation, and the wounded patient has been placed on the table, the apparatus is charged. Two medium-sized, fluffed compresses of gauze (which are renewed for each operation) are placed in the reservoir and saturated with 20 cc. of the mixture, poured from the graduate through the top aperture.

The cover is closed, the inhaler is gently placed over the face *with the air-vent wide open.* After two or at most three expirations, the air-vent is closed and the inhaler closely adapted. The rebreathing bag is fully distended. The period of excitation is either absent or negligible, even in alcoholics. In two minutes the time necessary for the preparation of the field of operation, muscular relaxation is complete, and the narcosis remarkably calm.

After the operation is begun nothing remains but to maintain anesthesia and watch the condition of the patient.

The initial dose of 20 cc. assures a period of at least from 8 to 10 minutes of anesthesia, after which, to maintain anesthesia, it is necessary to add 5 cc. of the mixture every 7 minutes. This dosimetric administration of the mixture is accomplished through the upper aperture of the inhaler without displacing it.

Ordinarily the air-vent remains completely closed, and is only opened when necessary.

The return to consciousness is rapid and complete. Nausea is rare and vomiting not more frequent than with chloroform. We have administered 500 anesthesias without untoward incident.

FROM THE BEGINNING of the war, Arthur Mills, of London, England, had considerable experience in the administration of anesthetics to soldiers in home hospitals, in the first instance, to soldiers in a war hospital suffering from wounds and invalided home from the fronts, and later to young soldiers in full training admitted to a camp military hospital to undergo some operation. Mills distinguishes between these two types of soldier patients and indicates his methods of anesthesia for handling them, as follows:

The two classes really differ considerably as regards type. The large majority of the former, writes Mills, have been confined to bed for at least a few days, and are *invalids*, and differ very little, as regards my subject, from the usual type of hospital patient in civil life. At the camp military hospital, on the other hand, we are constantly meeting with the young, athletic, well developed man of 18 to 21 years of age engaged in a period of intensive physical training. Frequently the operation is a trivial one, and admission to hospital the day previous to the operation is considered sufficient for the purposes of preoperative preparation. The nervous system of the young soldier is by no means stable. He is frequently far more *nervous* than a woman. His reflexes are exquisitely sensitive. He is in hard muscular condition. He is nearly always a heavy cigarette smoker. We have thus many factors which go to make up a type difficult to anesthetize safely and satisfactorily.

CONTRAINDICATIONS TO CERTAIN ANESTHETICS AND MIXTURES.

IT MUST AT ONCE be laid down in the most emphatic manner that for such cases induction of anesthesia with chloroform is strongly contraindicated. Should the attempt be made to anesthetize with chloroform, it will be found that the large majority of these men develop excitement and struggling and spasm of the limbs and respiratory muscles. If at the moment of onset of such a state of spasm a strong chloroform vapor has been inhaled, it may be retained in the pulmonary alveoli for a considerable time, the percentage of chloroform in the circulating blood may be raised to a toxic degree, and fatal symptoms may appear while the corneæ are still sensitive. The heart, indeed, gives way before breathing can be reestablished.

It is exceedingly doubtful, too, whether a mixture of chloroform and ether is safer than pure chloroform during the induction period. The difference in degree of volatility of the two substances forms the difficulty. If any anesthetic effect whatever is to be obtained from the ether element in the mixture, measures must be adopted to exclude the air to some extent, and exclusion of air is not permissible if the chloroform element be present in any degree. Again, if the mixture be administered by anything resembling the constant drop method, or if the successive *doses* poured on the mask be too frequently repeated, we must remember that the proportion of chloroform in the vapor inhaled by the patient is rising to an unknown extent. My experience, indeed, goes to show that the result obtained by induction with a chloroform and ether mixture is the same as that obtained with pure chloroform.

Induction with pure ether, again, is attended in these cases with considerable difficulty. A large proportion of them have a certain degree of pharyngitis from excessive cigarette smoking, and coughing and choking are common phenomena.

Nitrous oxid gas produces too light and evanescent an anesthesia in these robust subjects to form a satisfactory prelude to ether, and any attempt to prolong it by administering more gas results in undesirable cyanosis.

ADVANTAGES OF THE ETHYL CHLORID-ETHER SEQUENCE.

I HAVE COME TO THE conclusion, therefore, that an ethyl chlorid-ether sequence is the best method we can adopt for induction, and have devised a method of using this sequence which I should like to bring to the notice of others.

I do not think that the majority of administrators use ethyl chlorid in the most satisfactory manner. Although we quite realize that it is not the quantity of anesthetic used but strength of vapor inhaled that is the determining factor in producing anesthesia, I find that in books on the subject, such as Hewitt's and Buxton's, this principal is fully realized when discussing chloroform or ether, but it is thrown aside when treating upon ethyl chlorid. We are told,. for example, to give so many cubic centimeters to a child and so many to an adult. This method would be all right so far if we could be sure that the quantity of ethyl chlorid prescribed could always be vaporized in a desired and known quantity of air. We cannot be sure of this. Again, it is impressed upon us in administering chloroform and ether that the patient should be *gradually* put under with a steadily increasing strength of vapor. With the recognized methods of giving ethyl chlorid, on the other hand, there is nothing to prevent the patient getting the full strength of the vapor with his first inhalation, a really dreadful experience for the patient, and associated with considerable danger. For the past five or six years I have constantly used an inhaler for ethyl chlorid devised by Mr. C. J. Loosely, anesthetist, Hospital for Children, Great Ormond Street, and have given many hundreds of administrations, including about 300 to soldiers (early in the war) undergoing dental extractions. To have a stopcock fitted to the foot of the bag and this connected by rubber tubing with an ether bottle and bellows was an easy matter, and this forms the simple apparatus which I now use in giving the ethyl chlorid-ether vapor sequence.

THE APPARATUS USED.

TO INDICATE BRIEFLY how the apparatus is used, and quoting freely from Mr. Loosley's decription of his inhaler, about 3 c.cm. of ethyl chlorid are sprayed into the bag through the valve. This valve opens when the nozzle of the ethyl chlorid tube is pressed against it, and closes automatically immediately the nozzle is withdrawn, a tube below carrying the discharge well away from the face-piece. The face-piece is applied to the patient's face and the lever of the two-way cock kept in the down position so that the first few breaths of the patient are turned into the bag till it is about half full. The lever is now pulled upwards towards the face-piece and the patient breathes a dilute mixture of ethyl chlorid vapor and air. Dilute ethyl chlorid vapor is quite pleasant to breathe. A vapor sufficiently strong to produce anesthesia is pungent and produces a sense of suffocation. The vapor is now strengthened by spraying a little more ethyl chlorid through the valve, and still a little more until anesthesia is produced. The patient is now, as a rule breathing vigorously, but there is abundance of air in the bag and he can take a full breath without emptying it.

Using ethyl chlorid alone we can safely push the anesthetic till we have the usal signs, fixed eyeballs, dilated pupils, and insensitive corneæ—before removing the face-piece, and a good minute and a half or more of satisfactory anesthesia without trace of cyanosis will be obtained. Using it in sequence with ether a profound ethyl chlorid effect is not desirable, and as soon as unconsciousness is produced ether vapor may be pumped into the bag by means of the hand bellows. The strength of ether vapor can be varied within any limits by varying the degree of vigor of pumping and by the admission of more or less air at the face-piece. The apparatus is very economical as regards amount of ether used, a certain amount of rebreathing being involved, and, if desired, a much stronger vapor can be obtained than by using a Clover.

I contend that the method is a safe and highly satisfactory one for the induction of anesthesia, especially for the difficult type of patient under consideration, and it is also a satisfactory apparatus to use in maintaining anesthesia in the large majority of operations in a camp hospital.

PRECAUTIONS.

I THINK THAT MOST administrators will agree that quick inductions and closed inhalers tend to be associated with vigorous respiratory movements. In abdominal cases I therefore prefer a slow induction with chloroform and an open mask, changing to ether and an ether mask and the drop method before the dangerous period of excitement supervenes. Fortunately abdominal cases rarely come to operation while yet in a state of youthful vigor, and thus do not present the difficulties I have been discussing. In conclusion, I am convinced that the previous hypodermic administration of $\frac{1}{6}$ gr. morphin and $\frac{1}{100}$ gr. atropin is of considerable value. The hypodermic should be given no matter how trivial the operation may be.

Occasionally the nature of the operation demands the use of chloroform, but after the induction period is over and full narcosis has been produced these young soldiers take chloroform well.

THE AUSCULTATORY CONTROL OF VAPOR ANESTHESIA FOR OPERATIONS UNDER THE FLUOROSCOPE IN WAR SURGERY . APPARATUS FOR VAPOR ANESTHESIA AND AUSCULTATORY CONTROL . ADVANTAGES OF THE METHOD AND APPARATUS . METHODS OF GENERAL ANESTHESIA IN FACIAL SURGERY . MODE OF PREPARATION AND INDUCTION . THE LYING-DOWN POSITION . CHLOROFORM, C-E OR ETHER BY SHIPWAY'S WARM ETHER APPARATUS . STERILE ANESTHETIC . INTRATRACHEAL ANESTHESIA . KUHN'S TUBE . ETHER-OIL COLONIC ANESTHESIA . THE SITTING-UP POSITION . CHLOROFORM OR C-E AND OXYGEN BY SHIPWAY'S APPARATUS . ETHER-OIL COLONIC ANESTHESIA . SUMMARY . DROP-ETHER PHARYNGEAL ANESTHESIA AND APPARATUS FOR ASEPTIC ANESTHESIA IN PLASTIC FACIAL SURGERY . ROUTINE METHODS OF ANESTHESIA NOT ASEPTIC . THE NEWER METHOD AND APPARATUS . DETAILS OF ADMINISTRATION . CLINICAL CONCLUSIONS .

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FACIAL AND PLASTIC SURGERY in the war made very special demands on the surgeons, dentists and anesthetists. While vapor anesthesia was of great utility by the intrapharyngeal method, some sort of auscultatory control became necessary when the method was used in the dark-room under the fluoroscope. Arthur E. Guedel, of Indianapolis, Ind., working in the Vittel medical center hospitals of the A. E. F., thus recounts his effort to meet and solve the problems presented:

In an effort to meet a shortage of proper anesthesia apparatus for head surgery in the American Expeditionary Force, and at the same time provide a suitable device for the administration of the accepted high-volume, low-tension ether vapor for operations about the head and face, by the intrapharyngeal method, the illustrated apparatus was assembled from material that every base hospital has in stock. With a photo or drawing of this device at hand its assembling should not take more than an hour's time.

APPARATUS FOR THE AUSCULTATORY CONTROL OF VAPOR ANESTHESIA.

THE APPARATUS SUPPLANTS the high-priced and complicated (but good) devices now on the market for anesthesia in head surgery and produces results equally good in a simpler manner. The anesthetic novice will learn to operate it much more readily than the more intricate devices. Also the auscultatory tube, which is a feature in intrapharyngeal anesthesia that, I believe, has never before been used in this way, is a great help in the maintenance of an even and light anesthesia. It is of particular value in the dark-room for the removal of foreign bodies about the head, under fluoroscopic control. In fact it was the need of some method of control in dark-room anesthesia that prompted the conception of the auscultatory tube for this purpose. It has worked out so well that it has been used in anesthesia for general surgery as well as to facilitate the maintenance of even anesthesia.

There is less ether wasted with this apparatus than with those devices which employ a hot place for the vaporization of the ether.

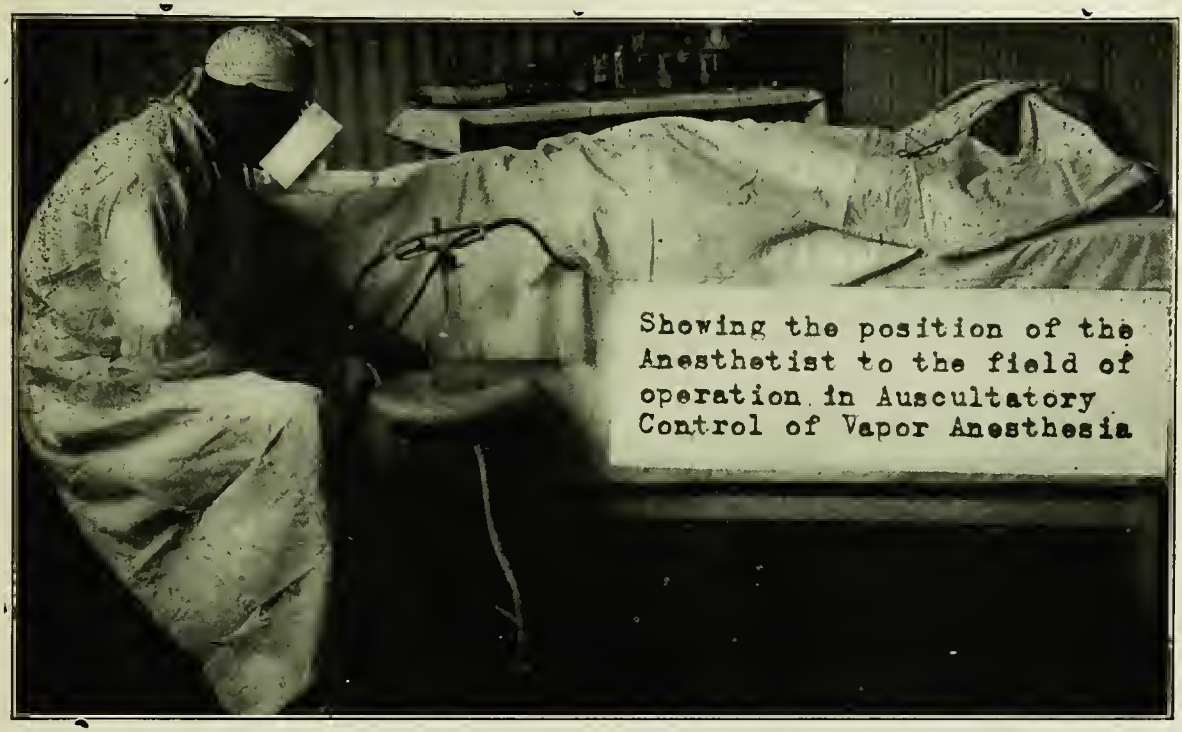

Fig. 1. Showing the position of the Anesthetist to the field of operation in Auscultatory Control of Vapor Anesthesia.

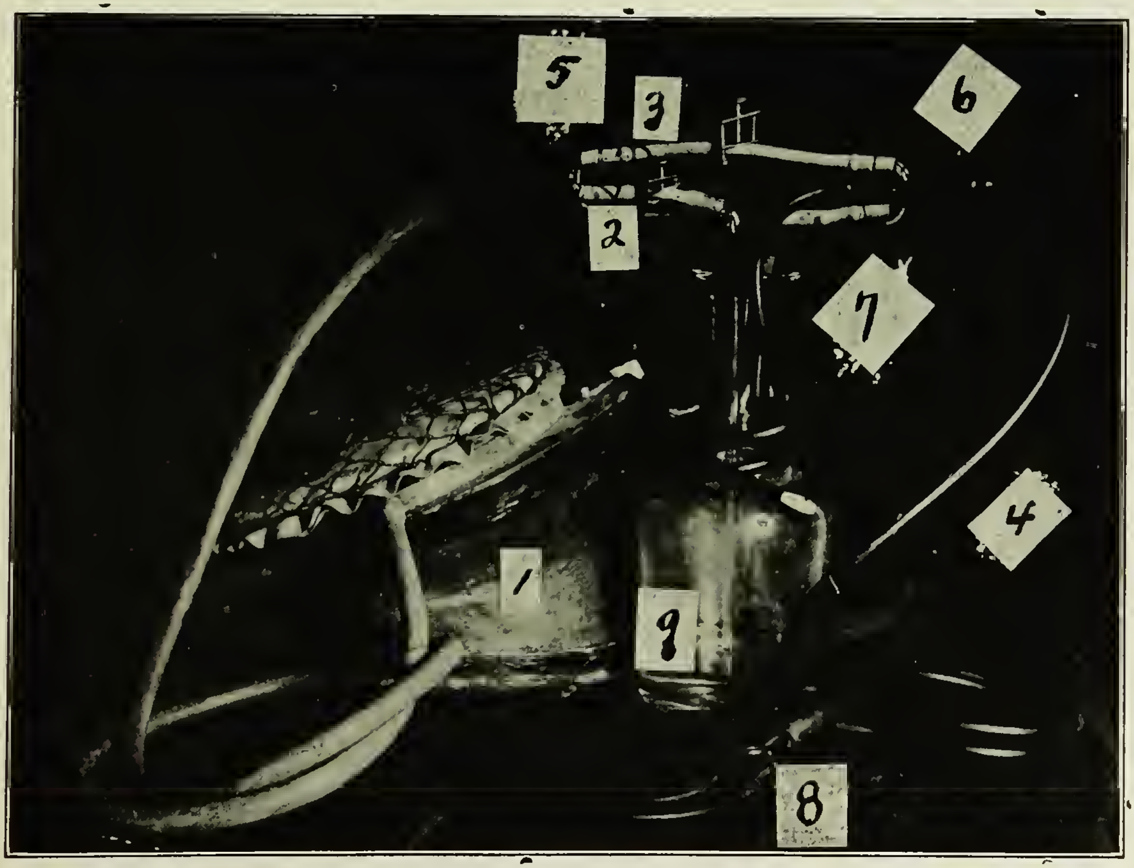

Fig. 2. Close-up of Apparatus fully assembled.

The apparatus consists of: (1) A dental foot-bellows; (2) a rubber tube through which air is carried into the other container. By manipulating the Dakin clamp on this tube the percentage strength of the ether vapor is controlled by regulating the amount of air passing through the ether; (3) a rubber tube through which a stream of air passes to the patient without passing through the ether container. By manipulating the Dakin clamp on this tube, in a direction contrary to that of the inlet tube, the strength of ether vapor delivered to the patient may be further controlled; (4) a rubber tube which carries the mixture of ether and air to the patient. This tube is 4 feet in length, thus enabling the anesthetist to sit well out of the way of the operators: (5) Dakin *U* glass distributing tube for the purpose of dividing the air current between the ether bottle and the patient; (6) Dakin *3-Way* distributing tube for the purpose of combining the streams of pure air and etherized air, and for the connection of the auscultatory tube; (7) The *Auscultatory Tube*, which conveys all the information that the anesthetist may need regarding the condition of the patient.

ADVANTAGES OF AUSCULTATORY CONTROL.

THROUGH THIS AUSCULTATORY tube the anesthetist may determine the following: (a) the patient's respiration; (b) whether or not the patient is swallowing, or (c) the patient's larynx is being flooded with mucus. This complication is rare with the high-volume, low-tension ether vapor method of anesthesia, because the end openings of the nasal tubes, when in position, are just above the larynx and the volume of etherized air is sufficient in most cases to blow all excess mucus into the mouth, from which it is either allowed to drain or is milked-out by pressure of the cheek; (e) the slighest effort of the patient to cough or vomit, indicating too light anesthesia, a matter that may be immediately remedied by deepening the narcosis; (f) the amount of air bubbling through the ether, thus helping to ascertain the strength of the ether vapor. This strength may also be determined by removing the auscultatory tube from the ear and smelling the ether vapor flowing through the tube, as it is always the same percentage strength as that being delivered to the patient. This auscultatory tube is particularly valuable in dark-room work, such as the removal of shrapnel under the fluoroscope. Here the anesthetist need not see the patient at all. He conducts the anesthesia entirely in accordance with the signs obtained through the auscultatory tube; (8) Dakin *U* tube connected with two catheters which are passed through the nostrils into the pharynx, and (9) the ether container.

The accompanying photograph shows the position of the anesthetist and apparatus with relation to the patient and the field of operation, with the auscultatory tube in place.

In conclusion, it may be remarked that the auscultatory tube furnishes more definite information as to what is going on in the patient's throat and chest than can be had in any other way, not excluding the use of the stethescope continuously over the chest. In cases where it is necessary to watch the pulse of the patient, this is easily accomplished at the wrist on the radial artery.

AS ANESTHETIST to Queen's Hospital, Sidcup, England, M. Wade, was fortunate in being able to try out the utility of various routine methods of general anesthesia in facial surgery in a large number of operations. From his experiences he has been able to summarize, in an exceptional way, the methods of anesthesia most applicable to different types of operations. Detailing his methods and conclusions in the Lancet, Wade observes that:

There are two main difficulties in anesthesia for operations on the face and lower jaw: (1) Maintenance of good airway; (2) difficulty of avoiding interference with aseptic technic and field of view of surgeon. In September, 1916, J. F. W. Silk suggested that cases in which blood was likely to find its way into the mouth during operation should be anesthetized in the sitting-up position. This was at once found very satisfactory. I have anesthetized in this way nearly 300 patients, and there have been no bad after-effects or complications. During the last five months we have endeavored to form an opinion as to which of the following methods of administering chloroform or ether to the various types of cases give the most satisfactory results.

Mode of Preparation and Induction.—This, for all methods except ether oil, is as follows:

Patients prepared in usual way, but without preliminary hypodermic injection of morphin. Atropin, gr. $\frac{1}{100}$, half-hour before induction. I first tried a series of cases with morphin gr. $\frac{1}{4}$ in addition to atropin; and then another series with atropin alone. The patients in latter series were certainly in better condition after operation; and I could not persuade myself that induction was much quieter, with morphin injection. I always induce anesthesia with chloroform, using an ordinary mask and drop-bottle, very often changing to mixture of chloroform and ether before the patient is under.

The following is the technic employed in the seven methods:

IN THE LYING-DOWN POSITION.

1. CHLOROFORM, C.E., OR ETHER, BY SHIPWAY'S WARM ETHER APPARATUS.

WHEN PATIENT IS UNDER, a small-size Hewitt's airway is introduced into mouth, then a small, bent metal tube is connected to rubber tube from Shipway's apparatus. End of metal tube is placed just inside mouth of Hewitt's airway. By this means it is possible, in majority of cases, to use a mixture of chloroform and ether and to keep patient under with one compression of bulb in every three or four inspirations. The anesthetist sits at one or other side of operating table, and, if necessary, can hold up patient's chin with one hand beneath towels, while having other hand free to work bulb of apparatus.

This method is useful for short operations when airway is good, and not likely to be interfered with by blood and mucus. It can be used in such operations as eye plastics, cheek plastics (not involving oral cavity), and epithelial inlays.

Contra-indications.—Plastics involving oral or nasal cavities. Operations on jaw (owing to possibility of interference with aseptic technic).

2. STERILE ANESTHETIC.

THIS METHOD WAS especially devised for such operations as wiring and bone-grafts in lower jaw. When patient is under the anesthetist washes up in exactly same way as surgeon, while someone else carries on with anesthetic. When necessary preparation of site of operation has been completed the anesthetist, in sterile face-mask, gown, and gloves, continues anesthetic with sterilized drop-bottle and mask. The mask is held in position beneath towels in one hand, and chloroform or C.E. dropped on to upper surface of towel with other. The hands may not be changed during operation.

In these cases the jaws are firmly splinted together in closed bite position. I have never experienced any trouble from tongue falling back; laryngotomy instruments are always ready, but it has never been necessary to use them. *Lately our dental surgeons have fitted splints which are joined together with screws, so that in cases of emergency the jaws can easily be separated.*

3. INTRATRACHEAL ADMINISTRATION OF WARMED ETHER VAPOR.

OWING TO NECESSITY for economy in ether it is not justifiable to use the open-ether method of induction in these cases, although I believe it to be the best. I think the catheter is more easily passed by the direct method with patient's head and shoulders on same level, *i. e.*, without having the shoulders raised, as is sometimes done.

This method is particularly useful for plastics involving the nasal and buccal cavities.

Contra-indications.—1. Contracted mandibular arch through loss of bone. 2. Trismus from various causes. 3. Jaws splinted together. 4.

Contracted mouths from gunshot wounds or burns. 5. Extensive lip plastics on account of interference with surgeon's manipulations.

Disadvantages.—1. Blood frothing up during respiration, especially in intraoral and palate operations. 2. Occasional spasms of larynx on introduction of catheter (probably owing to faulty technic).

4. KUHN'S TUBE.

THIS IS USEFUL FOR the same sort of cases as the intratracheal, with the exception of any lip plastics where its bulk precludes its use. In cases complicated by loss of bone in lower jaw where it is impossible to pass intratracheal catheter, this instrument is available either as a means of giving the anesthetic, or merely to act as an airway when ether-oil is administered per rectum.

Disadvantages of technic.—1. The larynx may be small. 2. Possibility of injury to larynx. Great care should be exercised during introduction. I have seen one or two cases of slight laryngitis after its use.

5. ETHER-OIL PER RECTUM.

PRELIMINARY PREPARATION.—These patients should have saline aperient on morning of day previous to operation, also dose of castor oil same evening. The following morning a simple enema is given, and rectum well washed out. A hypodermic injection of hyoscin gr. $\frac{1}{100}$, morphin gr. $\frac{1}{4}$, atropin gr. $\frac{1}{150}$, should be given half-hour before patient is brought to theater, when the ether-oil is immediately injected in a quiet darkened anesthetic-room as nearly as possible one hour before operation is timed to start.

I have tried two mixtures: (1) Ether 6 oz., olive oil 2 oz.; (2) ether 5 oz., olive oil 2 oz., paraldehyde 2 dr., and have come to the conclusion that the second gives the better results. The mixture is run in slowly through a funnel and tube attached to a soft rubber catheter. Catheter must not be passed more than four or five inches into rectum. Patients complain of less discomfort, if mixture be slightly warmed before introduction. I have only had one case in which injection was not retained.

If necessary, it is better to give chloroform or C.E. rather than ether as additional in these cases. If ether alone is given patient is more likely to have some bronchitis as after-complications; this applies especially to operations lasting for two hours or longer.

Immediately on patient's arrival back to ward rectum is very thoroughly washed out with warm water until no smell of ether can be detected, and no drops of oil seen in wash-out. I have *noticed that after long operations (over two hours) there has been some intestinal paralysis, which causes difficulty in washing out rectum, and subsequent abdominal distention and constipation. These effects are best treated by a hypodermic injection of pituitrin ½-1 c.cm.*

There is no doubt that this is a very valuable method of anesthesia for many operations in plastic surgery.

This is owing to its adaptability to surgeon's convenience during operation and on account of comparatively mild after-effect to patient. Another point in its favor is that airway is very rarely obstructed by tongue.

With regard to after-effects, the great drawback is length of time that patients take in coming round from anesthetic. This may be anything from two to four hours. But, on the other hand, vomiting is either absent, or only occurs once or twice; and patients themselves feel better than after an ordinary anesthetic. As to local complications in rectum, in a series of 100 cases there have been two patients who had slight bleeding and a few have complained of pain for two or three days afterwards. So far there have been no cases of proctitis.

This method is practically suitable for the following cases:

(1) *Bone Operations on Lower Jaw.*—(*a*) Because anesthetist does not interfere with surgeon; (*b*) vomiting is very distressing for patient who has had part of one of his ribs removed; (*c*) on account of length of operation.

(2) *Cartilage Implantations* when portion of rib cartilage is removed.

(3) *Very Long Plastic Operations* (*e. g.*, for extensive burns); there is less shock.

(4) Cases which, from previous experience, are known to suffer from excessive vomiting after other methods.

Contra-indications.—Operations where blood is likely to find its way into pharynx, except when this can be prevented by introducing a post-nasal plug or Kühn's tube and packing.

IN THE SITTING-UP POSITION.

(A) CHLOROFORM OF C.E. AND OXYGEN BY SHIPWAY'S WARM ETHER APPARATUS.

THIS WAS THE METHOD advised by Silk in September, 1916, and the technic is as follows:

An operating table must be obtained which will allow of head-piece being raised almost to perpendicular to form "back" of chair. To top of this can be fixed some kind of adjustable head-rest, to which the patient's head can be bound with flannel bandage. Patient sits on table and induction is carried out with mask and drop-bottle. When patient is under, his head is firmly bound to head-rest and anesthetic is then continued as follows:

An oxygen cylinder is connected by means of rubber tube to one arm of Y-shaped metal connection. To other arm is attached hand bulb belonging to Shipway warm ether apparatus, and from stem of the Y a rubber tube conveys either oxygen or air to Shipway apparatus. This arrangement economizes use of oxygen. If patient shows signs of coming round during operation, amount of anesthetic may be increased by passing air as well as oxygen through apparatus by means of hand bulb. The oxygen is allowed to bubble through chloroform or chloroform and ether at required rate.

The mixture of anesthetic vapor and oxygen is led to patient through piece of rubber tubing sufficiently long to reach from level of ordinary anesthetic table to top of patient's head; to latter end of tubing is attached No. 10 soft rubber catheter, which either is passed down one or other of nasal passages as far as upper part of pharynx, or, local conditions rendering this impracticable, it may be introduced into mouth through suitable metal tube.

Patients anesthetized in this position seem to require less anesthetic than when lying down. There is a risk of their vomiting during operation, and occasionally they have to be let down owing to faintness; both these are very exceptional. This position increases physical strain on surgeon, but on the other hand, it has three great advantages. It gives him an excellent view of patient's features; there is less bleeding, and, in the very large majority of cases, he has no anxiety concerning airway.

Long operations are no contra-indication to this position. I have had many lasting three hours, and one just over four, and the patients have nearly all been in good condition when operations were finished and did not suffer from any bad after-effects.

This method of anesthesia is particularly suitable for large plastic operations on lips and cheek plastics involving mouth. It is also useful where there is great loss of bone in mandibular arch.

(B) ETHER-OIL PER RECTUM.

THE PREPARATION AND induction are exactly the same as in Method 5 above. The patient is placed on operating table on his back. Care should be taken to ascertain that he is well under, otherwise some additional anesthetic should be administered by means of mask. When required depth of anesthesia is reached "back" of table is raised to perpendicular by easy stages. Additional anesthetic, if required, is given in same way as above (sitting-up position, A). I have only tried it four times, but although results in these cases were quite satisfactory, I cannot yet say whether it has any great advantages.

SUMMARY.

FROM THE ANESTHETIST'S point of view plastic operations may be divided into two main groups: those in which blood finds its way into the airway, and those in which it does not. I have endeavored in the following table to give a list of the various types of operations, together with the method of administration which we consider suitable for each case. Where there are alternatives the first is preferable:

Types of Operations.	*Methods of Anesthesia.*
Eye plastics	Chloroform or C. E. Shipway.
Eye plastic with cartilage implantations	Chloroform or C. E. Shipway. Ether-Oil.
Nose plastics—	
(*a*) Cartilage implantation, forehead	Ether-Oil.
(*b*) Bringing down nose	Ether-Oil, intratracheal.
(*c*) Where nasal cavity is involved	Ether-Oil, Kühn's tube.
(*d*) Where nasal cavity is not involved	Chloroform or C. E. Shipway.
Lip plastics	C. or C. E. and oxygen, sitting up. Intratracheal. Ether-Oil, sitting up.
Cheek plastics—	
(*a*) Involving oral cavity	Intratracheal. C. or C. E. and oxygen, sitting up. Ether-Oil, sitting up.
(*b*) Not involving oral cavity	Chloroform or C. E. Shipway.
Chin plastics	Intratracheal, Kühn's tube.
Jaw operations—	
(*a*) Wiring fractures	Ether-Oil. Sterile anesthetic.
(b) Bone graft	Ether-Oil. Sterile anesthetic.
(*c*) Either of above with jaws splinted together	Sterile anesthetic.
Extensive burns of face	Ether-Oil.

AT THE MEETING of the American Anesthetists in San Francisco, during the Panama Pacific World's Fair, A. E. Rockey, of Portland, Oregon, presented an apparatus for drop-ether pharyngeal aseptic anesthesia in plastic facial surgery, little dreaming that in a few short years he would be using it in connection with the restoration of war wounds. Later requirements even necessitated the development of a war model of his apparatus which was also successfully used. In a paper read by proxy during the Fourth Annual Meeting of the Interstate Anesthetists with the Indiana State Medical Association, at Indianapolis, September 25-27, 1918, and published in the Journal A. M. A., and the American Journal of Surgery, Anesthesia Supplement, July, 1919, Rockey, describes his apparatus and method of anesthesia as follows:

Plastic restoration of war wounds has made a new requirement of operative surgery. Sliding and turn-in flaps, bone transplants, secondary flaps and even skin grafts open tissues that are not infected. The mouth and particularly war wounds of the mouth always contain infective organisms. Newly opened tissues should, if possible, be protected from infection in these operations.

The anesthetic devices in general use have in the main proved satisfactory. In addition to conductive and local anesthesia, the chief reliance for general anesthesia has been the ordinary mask and pumps and blowers of various types and combinations.

ROUTINE METHODS OF ANESTHESIA NOT ASEPTIC.

BY NONE OF THEM, however, may one secure even an approximately aseptic field for operations about the mouth. None of them protect the field from mouth secretions and none of them permit the use of efficient antiseptics, for the reason that the respiratory tract is only relatively protected. An efficient antiseptic like tincture of iodin, is highly irritative and dangerous in the larynx and trachea, and the exhaust pump, no matter how good, cannot be depended on absolutely to remove every drop of fluid from the pharynx. It has become the custom, consequently to regard the mouth as a region that could not be sterilized and give the well vascularized tissues such credit for resistance to infection that aseptic operations were not only possible, but not necessary. In a measure the reasons might apply to the vaginal or anal region. Before operating on these parts, thorough cleansing and sterilization of the surface with strong antiseptics is the rule and operation without such precautions would not be considered standard procedure. The failure of surgeons to adopt the same method in oral operations is due to the in-appropriate methods of anesthesia in general use. *The same advantages may be obtained by providing a safe airway for respiration through which the anesthetic may be given and which will securely block the larynx from blood, or antiseptic strong enough to sterilize the surface, and which will, after the site of operation has been cleansed, protect it from reinfection by the mouth secretions.*

and gauze pack to pharyngeal anesthesia by drop-ether.

The inhaler I have devised for these operations consists of a curved airway adapted to the mouth and pharynx. The open and slotted end of which should be so placed that it rests just above the larynx back of the epiglottis. It is provided with a moveable joint. This permits the tube to be turned upward for operations involving the

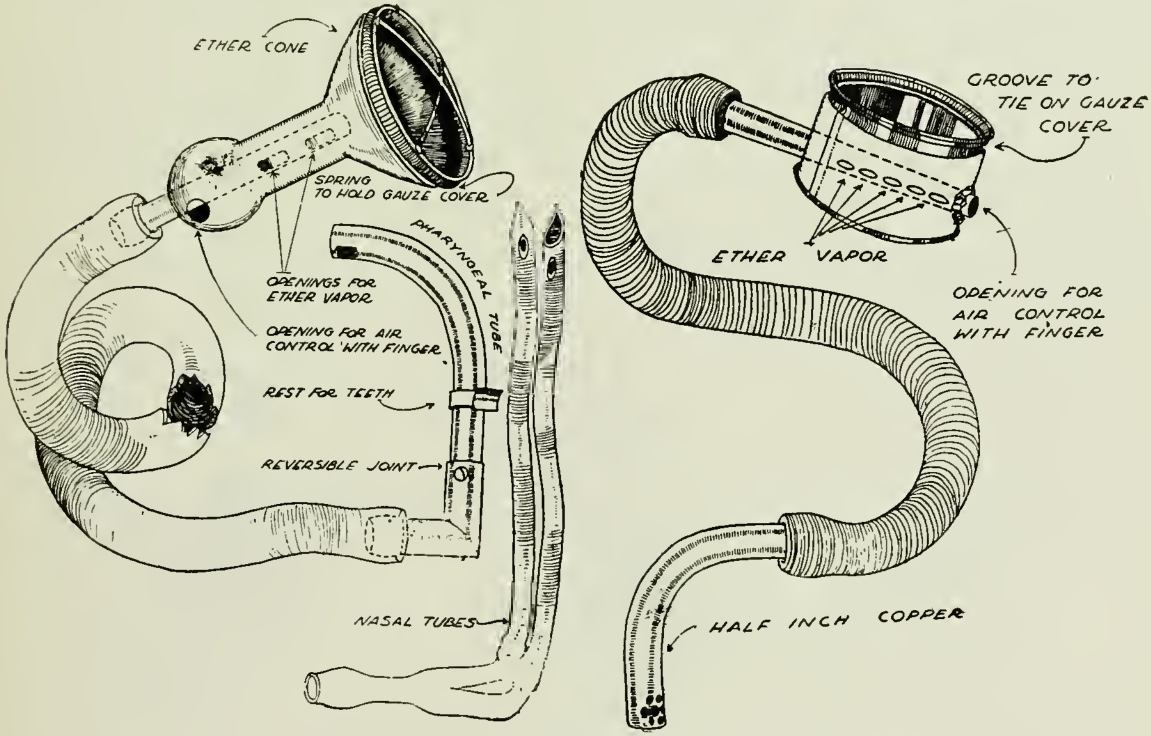

Fig. 1-2. The author's apparatus for drop-ether pharyngeal anesthesia and the war model.

THE NEWER METHOD AND APPARATUS.

ETHER INHALATION BY MOUTH through a large pharyngeal tube and a coffer dam of gauze packing, when properly placed, is superior to any other method in a very large class of these cases. It furnishes that efficient block between the operative field and the respiratory tract so necessary for the performance of ideal operations in this region and makes possible a degree of asepsis in the operation, not possible by any other method. It is now over 12 years since I first adapted a curved metal tube

mouth and neck and downward for the face and head. The nasal tubes are attached to a Y tube so curved that the stem may be firmly fixed over the nose by a strip of adhesive plaster, which insures stability and prevents obstruction in kinking. The pharyngeal tube has an inside diameter of half an inch and the connecting rubber tube an inside diameter of three-quarters of an inch. A practical working length for this tube is 30 inches. The funnel is of spun metal, provided at the top with crossed curved wires to support the gauze cover, and is surrounded by a groove in which fits a coiled string to hold the gauze in place. The inhalation tube is so far arranged that it is not possible to pour liquid ether into it. The opening to admit air directly into the inhalation tube is placed in the bulb of the handle at a convenient place for finger control.

The demands of war surgery have so taxed the manufacturing resources of instrument makers that it is difficult and expensive at this time to obtain this well-finished instrument. For this reason I have designed a war model, which is made by removing the handle from a common tin drinking cup and running a groove around the top, on which to tie the gauze. The ether vapor way is made by constructing a half-inch tin tube with five ¼-inch holes punched into the lower side. This is passed through holes in opposite sides of the cup near the bottom, leaving one end projecting about ⅛-inch to serve as a finger control of the air admixture and the other end projecting about 2½ inches on the opposite side. This end may be expanded to ¾-inch to fit the rubber tube. An airway may be made by bending a half-inch soft copper tube in the form of the original pharyngeal tube or using the rubber tube alone, in which case it must be protected by a wooden prop or mouth gag. Any of the other solid pharyngeal airways used by anesthetists make suitable substitutes. The large size of the tubes gives free movement to the air or ether vapor current, and provides for a moderate volume of rebreathed ether and air.

Year by year as experience has accumulated my satisfaction with the method has increased. Success may be atained only by minute attention to details. The extension of the respiratory tract across the operative field from the larynx to the ether cone requires first proper adjustment.

DETAILS OF ADMINISTRATION.

A SUFFICIENT PRELIMINARY HYPODERMIC of morphin and atropin should be given an hour before ether is to be administered. Complete third-stage anesthesia must then be produced with the ordinary mask. The pharyngeal tube is then introduced, or in the comparatively few, in which deeper access to the mouth is required, the nasal tubes are placed. The posterior part of the mouth is then well packed with gauze. Much depends on the thoroughness and care with which this is done. The gauze pack forms the necessary dam of protection, both for the respiratory tract and for the field of operation. The inhalation tubes, either pharyngeal or nasal, may be further held in place by an adhesive strip around or over and then at-

Figs. 3, 4, 5. Show the pharyngeal tube in position (3), and the type of plastic facial surgery for which drop-ether pharyngeal anesthesia is adapted.

tached to the forehead or face as the character of the operation permits. If this is carefully done a satisfactory anesthesia may be maintained without interference.

It is essential that the ether be given by some one competent to maintain safely such a degree of anesthesia as will prevent any attempt at vomiting, which might clog or displace the tube and break the asepsis of the operating field.

These requirements, while not difficult of accomplishment, demand careful attention, but the result is certainly worth while. We may expect safety in anesthesia, facility in operation and a degree of protection from infection that cannot be obtained by any other method.

CONCLUSIONS.

IN SAFETY THE supremacy of drop ether in many thousand of cases stands unchallenged. The inhaler herewith described, gives drop ether from what is practically an open mask, as the finger of the anesthetist at all times gives an instant touch control to the air admixture. This is by no means true of an ordinary funnel. The character of the respiration, which is the great indicator of safety in narcosis, is at all times apparent to the anesthetist by the sound of conduction in the tube.

When this method was first used the principal idea was to obtain a satisfactory anesthesia in these operations. The gauze pack in the mouth soon demonstrated the possibility of securing a degree of asepsis not possible without it.

A necessary preliminary is a careful cleaning of the mouth by the dental surgeon. Tartar should be scraped from the roots, and decayed, loose and abscessed teeth should be extracted, as should teeth within or about the diseased area. The greatest use for asepsis in these operations will be found in the reconstructive plastics that are required by war wounds of the face and jaws.

INSTRUCTION IN ANESTHESIA HAVING BEEN OMITTED IN MANY MEDICAL SCHOOLS AND HOSPITALS OUR BEST TRAINED MEDICAL MEN HAVE NO BASIC KNOWLEDGE OF ANESTHESIA AND NO EXPERIENCE IN ANESTHETIC TECHNIC. WE ARE NOT ONLY NEGLECTING TO TRAIN ANESTHETISTS FOR PRESENT AND FUTURE NEEDS BUT ARE FAILING TO FURNISH THE SURGEONS OF THE COMING GENERATIONS WITH THE KNOWLEDGE OF THE FUNDAMENTAL PRINCIPLES OF ANESTHESIA NECESSARY FOR THE EFFICIENT PERFORMANCE OF THEIR WORK. THE SURGEON OF THE PRESENT TIME, WHO EMPLOYS UNSKILLED ANESTHETISTS, JUSTIFIES HIS POSITION BY THE CLAIM THAT HE IS ABLE TO OVERSEE THE ANESTHESIA. THE SURGEON OF THE NEXT GENERATION WILL NOT HAVE HAD THE REQUIRED EXPERIENCE WITH ANESTHETICS TO UPHOLD EVEN THIS UNSATISFACTORY RELATION.

—*Albert H. Miller.*

GENERAL ANALGESIA BY ORAL ADMINISTRATION . THE PROBLEM INVOLVED . EXPERIMENTAL ANIMALS, DRUGS AND METHODS . CLINICAL DATA . CASE REPORTS . DISCUSSION . CONCLUSIONS . CHLOROFORM ANALGESIA BY SELF-ADMINISTRATION AS ADAPTED FOR DRESSING WOUNDS . THE SUPERIORITY OF SELF-INHALATION . RESULTS FOLLOWING CHLOROFORM ANALGESIA . EFFICIENCY OF OTHER MIXTURES . DOSAGE OF CHLOROFORM . REPETITION AND METHOD OF INHALATION . SUMMARY . ANESTHESIA OF EXPERIMENTAL ANIMALS BY THE SUBCUTANEOUS INJECTION OF ETHER-OIL . TECHNIC . DOSAGE . MINIMUM DOSE . MAXIMUM SAFE DOSE . SUMMARY.

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MANY WAR WOUNDS were accompanied by fractures of the bones and the importance of keeping such patients quite was universally recognized. If the dressing of such a wound was accompanied by severe pain it was customary at the Lakeside Unit A. E. F to produce nitrous oxid-oxygen or light ether anesthesia for at least the first few dressings, necessitating in most cases, because of limitation of apparatus, removal of the patient to the operating room. This usually meant pain and the danger of misplacing the bone fragments before and after dressings, as well as loss of time to surgeons, nurses and orderlies. To meet this problem, and aided by grants from the American Red Cross, H. T. Karsner, of Cleveland, O., and James T. Gwathmey, of New York City, working in the laboratories and Clinics of General Hospital No. 9, developed a method of general analgesia by oral administration, the following details of which they published in the British Medical Journal and the Journal A. M. A., April 6, 1918:

General analgesia, produced simply and quietly without taking the patient from his bed, is the logical solution of this difficulty, and the technic evolved as the result of this study makes it possible to administer the analgesic by mouth in perfect safety. It is, of course, applicable to practically all forms of painful dressings, and is being developed to embrace short surgical operations, such as resection of a rib, removal of foreign bodies, and revision of wounds. In such operations, however, it may be necessary to supplement the analgesia with novocain for the skin incisions, a hypodermic injection of morphin, or even by light inhalation anesthesia.

EXPERIMENTAL ANIMALS, DRUGS AND METHODS.

LOCAL CONDITIONS MADE it seem advisable to select rabbits as the animals for the preliminary work. The animals were tied to a board and the various substances given by stomach tube, after which the animals were immediately released and placed under observation.

Quinin and Urea Hydrochlorid (Nikalgin):

Weight of Animal.	Amount.	Result.
2200 gm. . .	4 c.cm.	No systemic effect.
2105 gm. . .	8 c.cm.	
2250 gm. . .	16 c.cm.	
1795 gm. . .	30 c.cm.	Unable to stand after 10 minutes and died in 8 to 17 hours.
2215 gm. . .	60 c.cm.	

Trional (dissolves in alcohol, 1 grain to 1.5 c.cm.):

Weight of Animal.	Amount.	Result.
2230 gm...	1 grain	Reflexes active.
2470 gm...	3 grains	Reflexes abolished in 1 hour; still on feet.
2175 gm...	6 grains	Reflexes abolished in 45 minutes, remaining so for 5½ hours; full recovery in 8 hours.
2460 gm...	9 c.cm. alcohol (control)	Reflexes partly abolished.

Morphin Tartrate (*in water*):

1810 gm...	½ grain ...	No appreciable effect.
2560 gm...	2 grains ...	
2000 gm...	3 grains ...	
2050 gm...	4 grains ...	

Paraldehyde:

1710 gm...	2 c.cm.	Dropped in 15 minutes, slept 4 hrs.; not analgesic.
2220 gm...	4 c.cm.	Dropped in 15 minutes; analgesic 6 hrs.; complete recovery.
	6 c.cm.	Died in 15 hours.

Ether in Olive Oil. 50 per cent.:

2430 gm...	5 c.cm.	Reflexes only partially inhibited, never off feet.
2170 gm...	15 c.cm.	Reflexes partially inhibited
2420 gm...	30 c.cm.	Reflexes completely abolished; apparently full recovery. On repeating dose next day, animal died in 30 minutes. Necropsy showed dilated stomach, with congestion, erosion, and submucous petechiae.
2060 gm...	20 c.cm.	Reflexes abolished in 6 minutes; apparently complete recovery in 1 hr. 16 min. Killed after 24 hrs., and necropsy showed same findings as in preceding animal.
2095 gm...	25 c.cm.	Reflexes abolished in 5 minutes; apparently complete recovery in 2 hrs. Killed after 24 hrs., with same result as in preceding animal.
—	30 c.cm. olive oil without ether	No effect. Killed after 24 hrs., and showed same condition in stomach as preceding animals.

Ether in Olive Oil. 25 per cent.:

Animal.	Amount.	Result.
No. 1....	30 c.cm.	Down in 12 minutes; reflexes not abolished.
No. 2....	20 c.cm.	Inco-ordinate.
No. 3....	10 c.cm.	No apparent effect.

All three animals were killed after twenty-four hours; stomach not dilated, fundus much congested and covered with much adherent mucus.

Paraldehyde plus 25 per cent. Ether in Olive Oil:

Weight of Animal.	Amount.	Result.
2100 gm...	1 c.cm. paraldehyde	No effect.
1880 gm...	10 c.cm. ether in olive oil	Down in 5 minutes; reflexes partially inhibited; practically restored in 10 minutes. Recovery in 25 minutes.
2170 gm...	Combination of above	Down in 5 minutes. Reflexes practically abolished in 10 minutes. Recovery in 30 minutes.
1950 gm....	Paraldehyde 2 c.cm. and 25% ether in olive oil oil 20 c.cm.	Down in 5 minutes; slept for nearly 2 hours.
2060 gm...	25% ether in olive oil 20 c.cm.	Down in 5 minutes; slept for 1 hour.

Other Combinations:

Weight of Animal.	Amount.		Result.
2000 gm...	Morphin tartrate	1 grain	All inco-ordinate, but no other effect.
	Ether	2.5 c.cm.	
	Albolene	7.5 c.cm.	
1965 gm...	Morphin tartrate	1 grain	
	Paraldehyde ...	1 c.cm.	
	Albolene	2 c.cm.	
2110 gm...	Paraldehyde ...	1 c.cm.	
	Ether	3.75 c.cm.	
	Albolene........	11.25 c.cm.	

These experiments were not conducted as experiments on the detailed physiology of analgesia, but simply for the purpose of demonstrating that analgesia can be produced by oral administration of proper agents. As will be seen, various combinations of drugs were not especially successful, and in rabbits the best results were obtained by the use of ether in oil. It was found, however, that this mixture produced acute gastritis in the animals, but further investigation showed that olive oil alone produced quite as severe a gastritis as when combined with ether. Knowing that olive oil is practically non-irritant to the human stomach, it was considered safe to proceed with the investigation on man. It was thought, however, that some mineral oils might be even less irritant in man, and accordingly the menstruum was changed to either liquid paraffin (albolene) or Russian mineral oil. The fact that there are said to be ether drinkers in Ireland and France who apparently suffer no more than alcoholics, made it seem additionally safe to try the mixture of the two for clinical work. Additional support was drawn from the fact that in many hospitals ether is being applied as a local dressing without deleterious results. Finally, a 65 per cent. solution of ether in oil has been used in many thousands of cases of ether-oil colonic anesthesia without any sign of local irritation to rectum or colon, as has been proven by proctologic examination, as well as by the fact that no case of dysentery or bloody diarrhea has been observed.

Clinical Data.

The following combinations have been tried clinically:

I. Ether, Liquid paraffin	āā flʒ iv
Aq. menth. pip.	*m* v
II. Paraldehyde	flʒj to iij
50 per cent. ether in albolene	q.s. ad.fl℥j
Aq. menth. pip.	*m* v
III. Ether	flʒ iijss
Albolene	flʒ iv
Aq. menth. pip.	*m* v

The mixtures containing paraldehyde were disagreeable to the taste and smell, the ether-oil very much less so, but the difficulty was soon overcome by following a suggestion by W. E. Lower. One ounce of port wine is placed in a glass and the analgesic in another glass The patient takes a mouthful of wine, holds it for about thirty seconds, rinsing the mouth so as to get the aroma in the upper air passages and the taste well established, and then swallows the wine. The ether mixture is then taken and is followed *immediately* by the remainder of the wine. Several wines and liqueurs were tried but port wine was found to be the most satisfactory. One of us (J. T. G.) and several other physicians have taken this "Lower sandwich," and have found it not disagreeable and to produce analgesia. As will seen from the following notes, numerous patients have been given it with excellent results. Only one patient has been nauseated, a man who was violently opposed to taking the wine. As opposed to that case it was given to another man, who had repeated attacks of vomiting, immediately after an attack. His dressing was done without pain, and his vomiting ceased permanently. All the cases have been able to take food and water shortly afterward, and even in patients much exhausted by infection there have been no deleterious after-effects. It was soon found that the paraldehyde served no useful purpose, and most of the dressings have been done with Formula I. While it is well not to give the analgesic immediately after a meal, no especial preparation of the stomach is necessary.

Under the general direction of W. E. Lower, the following cases were dressed in No. 9 (Lakeside, U. S. A.) General Hospital, American and British Expeditionary Forces, by Lieutenants B. I. Harrison and W. R. Barney. All the dressings were done without removing the patient from the ward.

CASE REPORTS.

Case I.—Soldier, age 36. Gunshot wound of right thigh, and infected compound comminuted fracture of femur. Previous dressings had been very painful, and the splint could not be changed without general inhalation anesthesia. Given: Paraldehyde flʒ j, ether flʒ iij, liquid paraffin q. s. ad fl℥. In fifteen minutes fell into a light sleep. The wound was dressed, splint removed, through-and-through wound irrigated with ether, gauze drain inserted down to femur, and Thomas splint applied with extension. The patient talked during the dressing, felt practically no pain, and suffered no nausea or other ill after-effects. The dressing was repeated in a similar manner every other day for four dressings, and in none of them was there pain or any alteration of pulse or respiration.

Case II.—Soldier, aged 28. Gunshot wound of left thigh, with compound comminuted fracture of femur. He was given same mixture as Case I, and fell asleep after twelve minutes. The

Thomas splint was removed and replaced, gauze packing removed, wound irrigated with ether, and another gauze pack reinserted. The patient groaned when the pack was reinserted, but after regaining complete consciousness said that he had felt no pain during the dressing. Three subsequent dressings were done on alternate days with no nausea or other after-effects, nor alteration of pulse or respiration. The patient complained of the taste of the mixture, but said it was far to be preferred to the extreme pain of the dressings.

Case III.—Soldier, aged 23. Gunshot wound of left leg—compound comminuted fracture tibia and fibula; through-and-through infected wound. He was given the same mixture as Case I, fell asleep after fifteen minutes and slept for thirty minutes, during which the dressings were done. Thomas splint repadded, packing removed and reinserted; ether irrigation. Two dressings were done without ill after-effects.

Case IV.—Soldier, aged 39. Gunshot wound of left thigh, through-and-through, with compound comminuted fracture of head of femur. All previous dressings extremely painful. Given paraldehyde flʒ ij, ether, albolene, āā flʒ iij. Wound cleansed, packing removed and reinserted. The patient groaned at one time, but had no later recollection of having had pain. The pulse increased from 108 to 110 and respirations from 26 to 28. No nausea. Three subsequent dressings on alternate days were equally painless and without ill after-effect.

Case V.—Soldier, aged 23. Gunshot wound of right leg, infected; compound comminuted fracture of tibia. Dressings very painful. He was given same mixture as Case I; dressing done with much less pain than before; the pulse rose from 100 to 116, and respiration from 24 to 26. A few days later the dose was repeated, and the patient slept through the dressing. No ill after-effects.

Case VI.—Soldier, aged 27. Gunshot wound of thigh; streptococcus infection. No fracture. Given morphin tartrate gr. ¼, ether flʒ iij, albolene flʒ iij, paraldehyde flʒ ij. Multiple superficial incisions were made for drainage with very slight pain, probably because of dressing following too soon after administration of mixture. The pulse rose from 110 to 120. The patient was vomiting before the mixture was given, but retained it and did not vomit afterwards.

Several other dressings are briefly summarized in the accompanying table.

Following the above experiments, one of us (J. T. G.) was ordered to a Casualty Clearing Station. The following cases from the service of Captain D. C. Taylor, R. A. M. C., illustrate some of the possibilities of the method:

Two almost parallel cases of penetrating wounds of the knee occurred on November 15th. Case 1 was given the usual inhalation ether anesthesia with the Shipway apparatus; Case II was given 1 oz. of 50 per cent. ether in liquid paraffin. Thirty minutes later a supplementary 2 drachms of chloroform were given by inhalation during the operation. The knee-joint was opened, pieces of comminuted patella removed, the joint irrigated with saline and closed. Both cases rested quietly for one hour after operation. Case I then complained, and required a hypodermic injection of morphin for the control of restlessness and pain. About the same time Case II awakened, drank some milk, and fell asleep again. Both patients slept until breakfast time. Case I drank some tea, but refused other food. Case II had tea, porridge, and bread-and-butter. Neither vomited afterwards, and both were evacuated to a base hospital in about four hours.

Two other cases of Captain Taylor's were given each a double dose of the mixture (2 oz. 50 per cent. ether in liquid paraffin). Each required only a few additional drops of inhalation anesthesia. The resultant analgesia after operation was a little more prolonged than with inhalation anesthesia. One of these patients was ready for operation in ninety seconds, and required 1 drachm of chloroform, given drop by drop, to "carry on" an operation lasting thirty minutes.

The substitution of chloroform for paraldehyde has been found to make even a more satisfactory mixture than the preceding. The following formula has been used in approximately thirty cases:

Chloroform	flʒ ss to j
Ether } Liquid paraffin }	āā flʒ iijss

It is not recommended at the present time to exceed this. It is our opinion that the toxic effect of this small amount of chloroform can be disregarded in military surgery.

DISCUSSION.

THE PHYSIOLOGY OF *general analgesia* by oral administration has not been subjected to an exhaustive investigation, but certain important facts should be borne in mind by those who contemplate using the method outlined. The oil and ether mix perfectly, and do not separate into layers. Baskerville has shown the rate of evaporation from minute to minute to be constant, so as to form a straight oblique line when plotted out. This holds true with different percentages of ether in the oil, in all cases assuming a constant temperature and exposed surface. It is therefore impossible for the patient to get an overdose at one time and an insufficient amount at another time. The total amount is not absorbed at one time; if it were, the administration of 2 ounces of 50 per cent. ether in oil would produce complete anesthesia, as there would be liberated 1 ounce of ether. Only a slight analgesia is obtained which, for operative procedures, must usually be supplemented in some way. Naturally, the surface for evaporation is greater in the stomach than is the case in the colonic method, and the absorption of ether more rapid. The total amount that may be given with safety by this method has not yet been determined. It is considered advisable for the present to supplement the method either by local anesthesia or the administration of small amounts of anesthetic by inhalation. But it is important to remember that the patient is as safe by this method as if the ether were in a container outside the body. All anesthetics are analgesics, and before the danger zone is reached the patient must become anesthetized; hence the patient in the analgesic stage is separated from the danger zone by the period of anesthesia. We consider analgesia by this method as safer than any method of anesthesia. If the anesthetist carries his patient to the *blear-eyed* snoring stage, he defeats the object for which this special method was devised, the object being to take advantage of the analgesic stage of any and all anesthetics used. If adopted it would release from the routine of administration of anesthetics a certain number of physicians who now, in military hospitals, devote their entire time to that work.

Nature of Dressing.	Administration.	Time of Dressing.	Result.	Pulse.		Respiration.		Pupils.	After-effects.
				B.	A.	B.	A.		
Deep wounds of both legs; deep drains	2.32 p.m.	2.50 p.m.	Good	84....	84	Normal		No effect	None.
Large excised painful back wound	2.32 p.m.	2.48 p.m.	No pain	92....	112	Normal		No effect	Nauseated and vomited.
Stump, adherent dressings (3 times)	3.03 p.m.	3.30 p.m.		120....	100	32....	20	No effect	None.
T.-and-T. wound leg, with drain	10.00 p.m.	10.20 p.m.	Good	No change		No change		No effect	None.
Abscess leg, multiple incisions	10.00 p.m.	10.20 p.m.	Good	No change		No change		No effect	Patient cried out but remained flaccid. Had little pain.
T.-and-T. drain leg	11.00 p.m.	11.15 p.m.	Poor	No change		No change		No effect	Only half dose given. Patient jumped and had pain.
Stump dressing	11.15 p.m.	11.30 p.m.	Fair	90....	99	No change		No effect	Patient cried out but had less pain than when done before.
Drains, foot	℥fl ss*								

*Had no effect whatever. B. = Before; A. = After.

CONCLUSIONS.

IT IS FELT that in so far as one can do so in a preliminary communication of this sort the following conclusions are justified:

1. General analgesia is safer than general anesthesia.

2. Fifty per cent. ether in liquid paraffin or other bland oil is probably the safest general analgesic, has apparently no deleterious effect upon the stomach, and is not followed by the nausea and vomiting that frequently accompany inhala-

tion anesthesia. Its effect may be enhanced by the addition of a small amount of chloroform (fl℥ ss to j). It may be given without unpleasant taste when "sandwiched" between mouthfuls of port wine.

3. The method is especially indicated during the dressing of painful wounds without taking the patient from his bed or ward, and, when supplemented, can be employed for surgical operations.

Note.—Our thanks are due to the medical director and members of the staff of No. 9 (Lakeside, U. S. A.) General Hospital, who have cooperated in this work. Major Alexander Lambert, Medical Director of the American Red Cross in France, on whose personal staff one of us (J. T. G.) had the pleasure of serving, has in many ways stimulated the working on this problem, and we take pleasure in expressing our warm appreciation of his interest and help.

THE WORK REPORTED in this paper by Torald Sollman of Cleveland, O., from the Laboratory of Pharmacology of the Western Reserve University Medical School, had been planned and completed before the article by Karsner and Gwathmey had been published. Publication in the Journal A. M. A. was delayed by Sollman to permit the clinical trial of his method of chloroform analgesia by self-administration under war and base hospital conditions. When such trials had progressed far enough to show that the method was effective, convenient and apparently safe, Sollman announced it in spite of the fact that the deep rooted fear of chloroform might tend to prevent its general adoption. He disclaimed the intention of reintroducing chloroform for general anesthesia, offering his method as a specific technic using a fixed dose for the specific purpose of analgesia only.

In approaching the problem, writes Sollman, I aimed to avoid the gastric administration, since the narcosis produced by this method would be likely to be more persistent than is necessary for the purpose. It was also doubtful to me whether an effective dose could be given without nausea or more serious danger. Gwathmey and Karsner, however, have apparently disposed of that question.

The use of morphin or scopolamin would be excluded for similar reasons: effective doses would be too dangerous and too prolonged, safe doses would be ineffective.

THE SUPERIORITY OF SELF-INHALATION.

IT SEEMS, ON *a priori* grounds, that a brief and harmless, but adequate analgesia could best be secured by the inhalation method, which introduces and eliminates the narcotic rapidly. The chief problem, therefore, appeared to be the evolution of a method of administration adapted specifically to this purpose; namely, one giving a rather superficial anesthesia, with perfect safety and comfort to the patient, and the minimum of technical difficulty of administration.

This pointed to the employment of *self-inhalation*. This carries with it an automatic safety device, in that the patient will be unable to continue the administration beyond the point at which consciousness is lost.

A method was devised of testing this administration on man, with various anesthetics and mixtures:

The presence and tolerance of pain was tested by touching the ordinary electrodes of a Harvard induction coil with the moistened tip of a finger, a strength of current being chosen such that the finger could not be kept on the electrodes normally by the exercise of an ordinary amount of will power.

The anesthetics were accurately measured in a conical graduate, taken up in a piece of cotton about the size of a lemon or larger, and held directly to the nostrils with the left hand of the subject. (Local irritation in all cases was negligible.) The subject then breathed deeply and quietly, occasionally testing the sensation.

ANALGESIC RESULTS FOLLOWING CHLOROFORM.

PRACTICALLY IDEAL RESULTS were secured by the use of 5 cc. of chloroform by this method. On several occasions the subject passed through the successive events of the ideal induction of anesthesia: the floating sensation, prickling, warmth, confusion, drowsiness; and in one case probably actual unconsciousness. In all the other administrations, the subject felt almost asleep, but gave answers to questions. The answers were appropriate, except when the effect was maximal, when they became incoherent.

The confusion began almost at once, and reached its maximum generally within five minutes. It began to lessen after about ten minutes. Then there remained a rather apathetic, drowsy state which disappeared only gradually; but inside of half an hour the subject was able to resume his ordinary occupations. There were no after-effects of any kind, except when the dosage was repeated in half an hour. In this case there remained some nausea and vertigo. The whole course of events is not in the least disagreeable, but rather seductive.

The analgesic phenomena are as follows: *Within a few minutes after starting, about the time when the floating sensation occurs, the painful stimuli are very much less appreciated. The stimulation is quite distinctly felt, at first as a painful sensation; but the mind does not attach any importance to it, so that the finger can be kept on the electrodes without difficulty. As the narcosis deepens, the stimulation is felt as smarting rather than as pain. The analgesia reaches its maximum in about four or five minutes. At this time most of the chloroform has evaporated, and the sponge becomes almost dry; and from this time on the analgesia diminishes, but the tolerance to pain is still very definitely greater than normal for about half an hour.*

EFFICIENCY OF OTHER MIXTURES.

THE CHLOROFORM WAS more effective than any of the other anesthetics that were tried. This applies both to the analgesia and to the mental effect. It caused distinctly greater confusion, relaxation and sometimes at least a distinct pallor.

Next in efficiency to the chloroform came the Hewitt chloroform-ether mixture (chloroform, 2 parts; ether, 3 parts by volume). When 10 cc. of this were inhaled, the effects approximated 5 cc. of the chloroform fairly closely; but they were not quite so deep. Five cc. of this mixture produced only a relatively slight effect. Ether itself in 10 cc. quantity is too weak, although it produces slight analgesia quite rapidly. Billroth's A. C. E. mixture (alcohol, 1 part; chloroform, 2 parts, and ether, 3 parts), 5 cc. is still weaker. I also tried the mixture stated as in use in the British hospitals for dressings, as described by Hirschman. (See papers by A. E. Guedel and P. Picard in this Year-Book.) Ten cc. of this acted scarcely stronger than the same amount of ether; perhaps a little more rapidly.

METHOD OF USE AND REPETITION OF DOSE.

FROM THESE OBSERVATIONS I would advise the clinical trial of the chloroform, in the manner that I have described, namely:

Five cc. of chloroform are measured, soaked up in cotton, and given to the patient, to be applied by him in the palm of his hand directly to the nose, his hand excluding the air as much as possible. The patient should be directed to hold it to the nose until the operation is completed. He should be instructed to breathe quietly and deeply. The dressing procedures can be begun between three and five minutes after starting the administration, and timed so as to be completed within twenty minutes

The dose should be measured accurately, since any tendency to guesswork or leeway would eventually lead to fatalities. Indeed, it might be advantageous to dispense the chloroform for this purpose in single dose 5 cc. ampules.

Repetition of the dose at the same sitting is to be avoided, but if absolutely necessary, the same dose may be given at the end of fifteen or twenty minutes, on a fresh piece of cotton. It is much safer, however, to abandon the use of chloroform in any cases in which a single dose is inadequate.

Inhalation from the hand was found much better than inhalation from a cup or similar mask, because it brings the vapor much nearer to the nose.

It must be remembered that the chloroform used in this way does not usually produce unconsciousness; and so long as there is some consciousness the painful stimuli are felt. The object of the chloroform in that dosage is to produce a drowsy apathy, in which the patient in the first place feels the pain less, and in the second place is more indifferent whether he feels it or not.

The fact that the patient has his attention occupied by his doing something himself that lessens his pain is a rather desirable feature for distracting his attention from the proceedings of the dressers.

Clinical trial of the method has established its value for the purposes for which it was devised, namely, as a convenient and brief analgesia for dressings or minor surgical procedures. It has not yet been compared extensively with the Gwathmey-Karsner method in the same service. It is quite conceivable that the field of the two methods is somewhat distinct.

SUMMARY.

THE METHOD PROPOSED consists in producing analgesia by the inhalation of a definite quantity of chloroform (5 cc.), measured as a single dose; and involving the usè of the patient's hand as a tight inhaling mask. It has given good results, both experimentally and clinically.

Of the various anesthetics, chloroform is best adapted to this self-inhalation analgesia.

The fixed dose should be rigidly followed, or rather should not be exceeded. No attempt should be made to produce full anesthesia by this method.

WORKING IN THE Research Laboratories of the American Red Cross in Paris, France, James T. Gwathmey of New York City, found it desirable to anesthetize experimental animals in the most humane, the simplest, quickest, and safest way; and he met these requirements by the subcutaneous injection of ether and oil. Gwathmey found that anesthesia may be thus produced quickly and safely, and could be made to last from 30 minutes to 2 hours, according to the dose employed.

TECHNIC.

AFTER VARIOUS MODIFICATIONS, the technic as finally employed by Gwathmey, consisted in giving the injection just back of the neck, against the direction of the hairs, which are not removed. Gwathmey, in the New York Medical Journal, gives further details as follows:

DOSAGE.

THE EXACT DOSE, according to body weight, for a given time, has been worked out as follows:

A predetermined dose of ether was given to two guineapigs, one weighing 900 grams and one weighing 310 grams. The larger animal was never completely narcotized (never off its feet), but its movements were incoordinated and it was wobbly and weak in the legs. After forty minutes it showed fair control of its limbs, and began to eat; it had fully recovered in an hour. The smaller animal was down in three minutes and was deeply narcotized for one hour (respiration lowered, with abolition of all reflexes), and it died at the end of two hours.

The maximum and minimum dose was determined by finding the amount of ether given in each instance cited in grams of body weight.

MINIMUM DOSE.

THE GUINEAPIG THAT WAS only partially anesthetized (weighing 900 grams) was given four cc. of ether and oil (oil fifteen per cent.). This may be expressed in the following equation:

$$\frac{85 \text{ per cent. of } 4.0 \text{ cc.}}{9} \quad \frac{3.4}{9} = 0.37 \text{ cc.}$$

The minimum dose, therefore, for guineapigs is 0.37 cc. of ether for each 100 grams of body weight. Several additional experiments verified this as the minimum dose.

MAXIMUM DOSE.

THE GUINEAPIG THAT DIED (weighing 310 grams) was given 4.0 cc. of the ether and oil mixture, and the amount of ether may be expressed as follows:

$$\frac{85 \text{ per cent. of } 4.0 \text{ cc.}}{3.1} \quad \frac{3.4}{3.1} = 1.1 \text{ cc.}$$

This is equivalent to 1.1 cc. of ether for each 100 grams of body weight.

The two following experiments, in addition to the one already cited, verified the maximum dose:

One guineapig, weighing 335 grams, was given 4.3 cc. It was down in four minutes, anesthesia lasted two hours and fifty-two minutes, and death followed three hours later. Another guineapig, of the same weight, was given the same dose. It was down in four minutes, anesthesia lasted one hour and twenty-six minutes; recovery was complete but tardy—too deeply narcotized.

Thus, of three animals given the maximum dose, two died, and the third was too deeply narcotized at all times. These experiments established the maximum dose of guineapigs.

MAXIMUM SAFE DOSE.

THIS WAS OBTAINED by striking an average between the minimum (0.37 cc.) and the maximum (1.1 cc.) as follows:

$$\frac{1.1 \text{ plus } 0.37}{2} = \frac{1.47}{2} = 0.74 \text{ cc.}$$

Therefore, 0.74 cc. of ether for each 100 grams of body weight was found to be the maximum safe dose for surgical anesthesia, lasting from one to two hours. Deviations of course may occur with faulty technic and with animals of different vitality. All animals given this maximum safe dose made a complete recovery from the anesthetic.

Fourteen experiments were carried out with the maximum safe dose. All animals were given a dose corresponding to 0.74 cc. of ether, or 0.87 cc. of the ether-oil mixture, for each 100 grams of body weight. The mixture contains eighty-five per cent. ether and fifteen per cent. olive oil. Eight of the fourteen animals were anesthetized over one hour. Four of these eight were down two hours; one an hour and a half. Two of the fourteen were down thirty minutes and over; three, ten to twenty-two minutes, and one was not anesthetized at all, because of leakage at the point of injection.

A second series of experiments was conducted with the object of ascertaining if a shorter period of anesthesia could be satisfactorily obtained with a smaller dose. This is the average between the maximum safe dose (0.74 cc. of ether for each 100 grams of body weight) and the minimum dose (0.37 cc. of ether for each 100 grams of body weight); it is 0.55 cc. of ether, or 0.65 cc. of the eighty-five per cent. ether-oil mixture, for each 100 grams of body weight. This corresponds to one-half the maximum dose. Nine guineapigs were anesthetized with this amount. Of these, five were anesthetized over one hour, the longest time being one hour and twenty-four minutes; one, forty-three minutes; one, fifteen minutes; one died; one was not anesthetized.

A third series of experiments was conducted with a still smaller dose—the average between 0.55 cc. and 0.37 cc. of ether, which is 0.46 cc. of ether, or 0.54 cc. of the eighty-five per cent. ether-oil mixture, for each 100 grams of body weight. Twelve animals were anesthetized with this amount. Of these, nine were anesthetized over thirty minutes, the longest time being fifty-nine minutes. The shortest time was fourteen minutes. Two died.

Six more experiments, with a still smaller dose, were so inconclusive that it was decided that the practical minimum dose for anesthesia was represented in the preceding series.

SUMMARY.

THE FOLLOWING DOSES have been determined for guineapigs, *for each 100 grams of body weight*, the eighty-five per cent. ether with fifteen per cent. olive oil being the mixture used in the experiments:

1. *Maximum safe dose.*—Anesthesia of one to two hours: 0.74 cc. of ether, or 0.87 cc. of eighty-five per cent. ether and fifteen per cent. oil mixture (or 1.00 cc. of seventy-five per cent. ether and twenty-five per cent. oil mixture).

2. *Medium dose.*—Anesthesia for about one hour: 0.55 cc. of ether, or 0.65 cc. of eighty-five per cent. ether and fifteen per cent. oil mixture (or 0.72 cc. of seventy-five per cent. ether and twenty-five per cent. oil mixture).

3. *Minimum practical dose.*—Anesthesia of about thirty minutes. 0.46 cc. of ether, or 0.54 cc. of eighty-five per cent. ether and fifteen per cent. oil mixture (or 0.60 cc. of seventy-five per cent. ether and twenty-five per cent. oil mixture).

THE DEGREE OF DANGER ATTENDING THE USE OF ANESTHETICS IS STILL UNKNOWN. THE MORE POSTOPERATIVE DEATHS ARE STUDIED, THE MORE EVIDENT IT BECOMES THAT A CONSIDERABLE PROPORTION OF THE MORTALITY IS DIRECTLY OR INDIRECTLY DUE TO THE EFFECTS OF THE ANESTHETICS. IN MEDICAL SCHOOLS, HOSPITALS AND IN THE MEDICAL PRESS THERE IS A DISPOSITION TO PAY LESS RATHER THAN MORE ATTENTION TO THE SUBJECT OF ANESTHESIA. THE MEDICAL PRECEPTOR, WHO FORMERLY GAVE HIS STUDENTS INSTRUCTION IN ANESTHESIA, IS NO LONGER RECOGNIZED. MEDICAL SCHOOLS NEGLECT ENTIRELY TO GIVE INSTRUCTION IN ANESTHESIA OR DIMISS THE SUBJECT WITH A FEW HOURS' CONSIDERATION. THE NEGLECT OF ANESTHESIA IN MEDICAL SCHOOLS IS PARTLY DUE TO A LACK OF COMPETENT INSTRUCTORS IN THIS DEPARTMENT. IT IS CHARACTERISTIC OF MODERN METHODS OF EDUCATION THAT COURSES OF INSTRUCTION DEPEND UPON THE AVAILABILITY OF INSTRUCTORS RATHER THAN UPON THE NEEDS OF PUPILS. THIS CONDITION PREVAILS WHILE THE COMBINATION OF PHYSIOLOGY AND PHYSICAL CHEMISTRY, WHICH PROVIDES THE FOUNDATION FOR THE STUDY OF ANESTHESIA, CAN BE MADE THE MOST INTERESTING COURSE IN THE MEDICAL CURRICULUM.

—*Albert H. Miller.*

THE VALUE AND SCOPE OF LOCAL ANESTHESIA IN BASE HOSPITAL SURGERY . ADVANTAGES OF LOCAL ANESTHSIA . METHOD OF PROCEDURE . TYPES OF CASES . SUMMARY . LOCAL ANESTHESIA FOR PENETRATING WOUNDS OF THE SKULL AND BRAIN SURGERY . TECHNIC OF THE OPERATIVE PROCEDURE . LOCAL VS. GENERAL ANESTHESIA . ALKALOIDAL AMNESIA AND LOCAL ANESTHETIC SOLUTIONS . ESSENTIALS FOR SUCCESS . VALUE OF BLOOD PRESSURE . THE EXCISION AND SUTURE OF SUPERFICIAL GUNSHOT WOUNDS UNDER LOCAL ANESTHESIA . TYPES OF WOUNDS . METHODS OF HANDLING . PRELIMINARY TREATMENT BEFORE ATTEMPTING SUTURE .

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EDITORIAL ABSTRACT
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LOUIS J. HIRSCHMAN, of Detroit, Mich., who contributed such an interesting paper on local anesthesia in rectal surgery to the Year-Book, 1915-16, had an extended opportunity in the world war to give local anesthesia a thorough try-out in military surgery. Hirschman considers that among the many interesting surgical methods revived and elaborated through stress of military needs the employment of local anesthesia has been of great value in the surgery performed in a military hospital. In a contribution to the Journal of the Michigan State Medical Association, 1919, Hirschman thus elaborates on his experiences:

Base Hospital 17, Harper Hospital unit of Detroit, was located in a city of 130,000 inhabitants. This city was a great railroad center and was on the direct line traversed by many of the American Expeditionary Forces in going to and from the front. Many thousand troops were encamped in the vicinity of this hospital, and among those freshly arrived from the U. S. A., it was not at all infrequent to find cases of hernia, rectal diseases, abscesses and other conditions met with in civil practice. The prevalence of coughs, colds and pulmonary diseases in France, and the susceptibility of the freshly arrived American troops to the same, made the employment of general anesthesia impossible in many cases requiring surgical measures for their relief.

ADVANTAGES OF LOCAL ANESTHESIA.

FOR YEARS THE writer has been employing local anesthesia in the treatment of diseases of the rectum and anus, as well as in the radical treatment of hernia. On account of its many manifest advantages over general anesthesia, it had been used in suitable cases as the anesthetic of choice in civil practice. In a war hospital where expedition in the handling of surgical cases, minimized hospital confinement, and early return to duty are of prime importance, anything which would hasten the desired ends, was of distinct benefit. Added to this was the prevention of the great danger of post-anesthetic complications, involving the lungs and kidneys, as well as the fact that on account of the absence of post-operative vomiting, the patient's nutrition could be build up so much sooner. Another important advantage is the fact that the anesthetist can be dispensed with. This releases a medical officer for other more important duties. An operation under local anesthesia can be performed more rapidly than in the time allowed for the administering of a general anesthetic and of performing an operation together. This meant more surgical operations could be performed in the same length of time.

In addition to the surgical procedures mentioned above, many operations on the scalp and skull, rib resections, amputations of fingers, and secondary suture of wounds of considerable extent, excision of infected wounds, operations for phimosis, varicocele and bubo were performed readily under local anesthesia.

In the author's surgical service, the average time required for an operation for inguinal hernia was seldom over twenty-five minutes. Five or six rectal operations were performed in one hour and the average secondary suture required about the same time. Rib resections were completed in fifteen minutes and colostomies and the operation for appendicular abscess were performed in fifteen minutes.

METHOD OF PROCEDURE.

THE EMPLOYMENT of a hypnotic before operations under local anesthetic is of prime importance. The administration of twenty grains of chloretone one hour before operating, or of a quarter or third of a grain of morphin one-half hour before operating was the author's usual practice.

The patient would come to the operating room in a quiet tranquil frame of mind His ears were muffled with cotton and a towel placed over his eyes and all unnecessary noises and conversation eliminated. If, however, a patient wished to converse with the operator, he was allowed to do so, and oftentimes, the operation took on more of the character of a social visit, than that of a surgical procedure. Patients would leave the operating room smoking cigarettes and would go back to their wards cheering up the patients who were to follow.

The absence of after-pain was a very pleasant feature of the employment of local anesthesia. the solution used was one-quarter of one per cent. novocain to each ounce of which was added six drops of solution of adrenalin chlorid. It is of the greatest importance to use sufficient solution to secure pressure anesthesia and important nerves such as the ilioinguinal in hernia should be well blocked by perineural infiltration.

TYPES OF CASES.

ANY OF THE operative measures used under general anesthesia in the treatment of hernia can be just as well employed under local. The average time required for the hospitalization of a hernia case where local anesthesia was employed in its cure was reduced one week. The value of this saving of time in military life is of great importance and in civil life it should be equally so.

Sepsis was practically unheard of, in fact did not occur as often as in cases operated under general anesthetic, which the author believes is due to the fact that there is less handling of the tissues under local than under general anesthesia.

In rectal surgery, it is unnecessary to dilate the sphincter. The employment of local anesthesia by its relaxation of the sphincter allows a better field for operative measures than the divulsed and damaged sphincter of the old régime.

Moreover the patient in most of the cases is allowed to be up and about after the first twenty-four hours. Convalescence and an early return to military duty is hastened. Patients after most operations performed under local anesthesia, seem to vie with one another in the speed with which they could be returned to duty.

In the surgical treatment of war casualties, the removal of foreign bodies, such as machine-gun bullets and shell fragments was very easily accomplished. The most suitable cases were those in which localization by the x-ray demonstrated the presence of foreign bodies in the soft structures and not embedded in bone.

Suturing of lacerated wounds, particularly of the scalp was a very favorable operation under local anesthesia. Débridement, or the excision of devitalized tissue in a wound, could be done surprisingly well, provided the wound was not too extensive or involved too much muscle.

Secondary suture of superficial wounds was an ideal procedure under local anesthesia.

SUMMARY.

TO RECAPITULATE, any operative procedure which can be done just as thoroughly under local anesthesia as under general anesthesia, should be performed for the following reasons:

1. It is safer.
2. It can be performed more rapidly.
3. Shock is absent.
4. Fewer assistants are required.
5. After-pain is absent.
6. Patients can take nourishment immediately.
7. Recovery is hastened.
8. Convalescence is shortened.
9. Thers is no fear of anesthesia.
10. Less handling of the tissues means less danger from sepsis.
11. The mental attitude is better toward local than general anesthesia, which materially assists in his convalescence, and in a ward is reflected on his fellow patients.
12. Post-anesthetic complications are absent.

LOCAL ANESTHESIA CAME to be used more routinely in military surgery for operations on the skull and brain than for almost any other procedures. It is for this reason that this brief editorial abstract of the work of such authorities as Harvey Cushing, H. M. W. Gray, and J. Anderson is herewith included in the Year-Book.

Major Harvey Cushing, director of U. S. Army Base Hospital No. 5 in France, has enjoyed clinical advantages that make his contribution on Penetrating Brain Wounds (British Medical Journal, February 23, 1918) of much more than ordinary interest. Aside from the purely surgical features of Cushing's conclusions, drawn from an experience of some 225 recorded cases, his use of local anesthesia is perhaps the most significant point in the technic of his operative procedure.

TECHNIC OF THE OPERATIVE PROCEDURE.

DURING THE SHAVING of the head, possible an hour before the patient's turn will come, a sedative is given, 1/3 grain of omnopon (pantopon) usually being sufficient, though this may be repeated if the patient is very restless or obstreperous. Then 15 or 20 minutes before the operation, in the lines of proposed incision, Cushing infiltrates the scalp with a 1 per cent. procain and adrenalin (15 drops to 30 cc.) solution in the sub-aponeurotic layer.

There exists a difference of opinion regarding the relative merits of general *versus* local anesthesia for cranial operations. Cushing confesses to an original prejudice in favor of inhalation narcosis, but his experience in war surgery has led him completely to alter his view.

LOCAL VS. GENERAL ANESTHESIA.

GENERAL NARCOSIS increases intracranial tension, which exaggerates the difficulties of an operation already difficult enough. It increases bleeding from the scalp, which, with the procain-adrenalin solution is rendered negligible. It encourages the use of rougher methods, which a patient under local anesthesia would not tolerate, and which, therefore, are in all likelihood harmful. It encourages speed, which is to be decried if employed at the expense of delicacy. It leaves many patients, particularly those with threatened respiratory difficulties, in a condition in which inhalation troubles are prone to occur.

Until recovery from a general anesthetic is complete every patient should be under close observation, and this, at a Casualty Clearing Station at least, is impossible. It is very rare, and then only in case of semi-conscious patients or those with restless irritability, that the operation cannot be carried through under local anesthesia, though this necessitates more gentle manipulations than those usually employed, particularly during the process of removing the area of cranial involvement.

ALKALOIDAL AMNESIA AND LOCAL ANESTHETIC SOLUTIONS.

COLONEL H. M. W. GRAY, R. A. M. C., has found omnopon (pantopon) preferable to morphin for pain relief and alkaloidal amnesia, because its depressing effect on the vital centers and on metabolism is not manifest to anything like the same degree. Two-thirds of a grain of pantopon is equivalent in sedative action to about ¼ to ⅓ grain of morphin.

J. Anderson (British Medical Journal, July 14, 1917), adds magnesium sulphate to his local analgesic solution, utilizing the following formula:

Procain	0.75 per cent.
Magnesium sulphate ..	0.50 per cent.
Normal saline	100. per cent.

To each 30 mils of this solution 1 mil of adrenalin solution (1 to 1,000) is added. This provides a somewhat longer duration for the obtunding effect.

ESSENTIALS FOR SUCCESS.

THE MAIN FEATURES of the routine procedure for handling penetrating brain wounds developed by Cushing from his extended experience and those of other operators, are as follows: (1) The removal *en bloc,* rather than piecemeal, *of the area of cranial penetration.* (2) The detection of the in-driven bony fragments by *catheter palpation* of the track, rather than by the exploring finger. (3) The *suction method of removal of the disorganized brain,* thereby cleansing the track of the so-called pulped or devitalized tissue, the retention of which, as is the case with dead tissue anywhere, favors infection. (4) The use of *dichloramine-T in oils as an antiseptic* particularly suitable for infections in the central nervous tissues.

In addition to these more essential features of the operative procedure, the routine preoperative neurological study of the case; stereoscopic x-ray negatives; the shaving of the entire scalp; the invariable use of *local anesthesia* supplemented with alkaloidal amnesia; preferential tripod rather than flap incisions; foreign body extraction with the magnet when possible; closure of the wounds with buried sutures in the galea; the dressing of all serious cases in the operating room rather than in the wards—all these steps, though less novel, were found to be contributory to the successful outcome of the more severe cases.

By utilizing two or three tables for each operating team, series of cases may be handled without delay, the neurological examination, x-ray exposure, shaving of the scalp, hypodermic and local anesthesia injection, all of which are time-consuming, being carried out during the operating period of the previous case.

It is to be noted especially that Cushing's entire technic has been an elaboration of the velvet-touch method of operating, which is an essential for all procedures done under local anesthesia. In this connection it should also be emphasized that the use of alkaloidal amnesia, puts the patient in a sufficiently drowsy condition not to mind the use of trephine, drill, or ronguer, the effects of which are somewhat distressing when local anesthesia is used alone.

BLOOD PRESSURE.

THE SUMMARY OF THE results of examinations of blood pressure in head wounds, in the report of the British Medical Research Committee, December 25, 1917, is of interest in connection with the subject under discussion. Fraser and Cowell conclude that:

The blood pressure subsequent to wounds of the head is apt to be unstable. If operation is performed under general anesthesia before the blood pressure has become stable, disaster, is liable to ensue. The possibility of such an ill result can be diminished by delaying operation until the blood pressure has become stable or *by performing it under local anesthesia, supplemented with scopolamin-morhpin.*

DEBRIDEMENT AND EARLY SUTURE of wounds were two of the successful innovations of war surgery. Fortunately it was found that a certain number of superficial gunshot wounds leant themselves to excision and suture under local anesthesia, and Sam Brock of Cleveland, O., writing in Surgery, Gynecology and Obstetrics, May, 1918, about his experiences with this method of handling the wounded at General Hospital No. 9, Lakeside Unit, claims the following advantages:

First, it makes possible many minor operations which ordinarily would not authorize a general anesthesia; *second*, it saves dressing material; *third*, it prevents the formation of scar tissue; *fourth*, it saves time, the most potent factor in war surgery.

TYPES OF WOUNDS.

SUPERFICIAL GUNSHOT WOUNDS may be classified as penetrating, perforating and gutter, and are caused in the majority of cases by high explosives. They are all more or less infected. A high explosive, bursting into many fragments and traveling at a comparatively lower velocity than the bullet, causes ugly gashes, tearing and devitalizing the tissues and depositing along its course fragments of clothing, earth, and débris. The rifle bullet wound is comparatively clean and usually can be distinguished from the sharpnel wound.

Superficial wounds are frequently given little consideration at Casualty Clearing Stations. A hasty dressing, dry, or moistened in eusol, is applied, or the wound is *bipped*. The patient arrives at a Base Hospital within 24 to 48 hours. Many wounds show marked infection by this time; others with less ample drainage require immediate operation.

The most insignificant looking high explosive or shrapnel wound of the penetrating and perforating types may cause serious consequences. The early suture of any gunshot wound which cannot be kept under observation, is rarely justifiable. Many wounds sutured at the Casualty Clearing Stations require immediate removal of sutures when the patient arrives at the Base Hospital.

METHODS OF HANDLING.

THE POSSIBILITY OF EXCISION and suture of any superficial wound depends on its size and location. Those areas where skin flaps are most readily secured, facilitating approximation with a minimum degree of tension, heal most rapidily.

Many wounds can be excised completely intact. Such wounds may be closed without fear of subsequent infection. Many wounds that have been excised *en masse* at the Casualty Clearing Station have been closed successfully shortly after arrival at the Base.

Even when dressed every day, the average superficial unsutured wound requires from 3 to 6 weeks to heal. The time saved in the healing of these wounds by excision and suture is apparent. The dressing material saved is considerable. The earlier the wound can be sutured the better. After two weeks enough scar tissue has been formed to make excision difficult.

The superficial wounds shown in the accompanying illustrations were excised and sutured after 4 to 6 days' treatment. The operations were done in a clean theatre where no pus cases were handled. The time for operation was determined by the gross macroscopic appearance of the wounds, no cultures having been made. The patients were not confined to bed, but came to the dressing tent, after, as well as before operation. It was found, however, that wounds of the arm, put at rest with splint and sling, made more rapid recovery. Wounds of the face and neck without exception healed by first intention.

Novocain 1:200, properly infiltrated, produces complete anesthesia. An area 5 centimeters in width can be blocked in one line about the wound.

TREATMENT.

THE INFECTION WAS controlled by the use of hot dressings and subsequently 65 per cent. alcohol dressings. Gauze was boiled in 4 per cent. boric solution, wrung out and applied to the wounds. Dressings were changed three

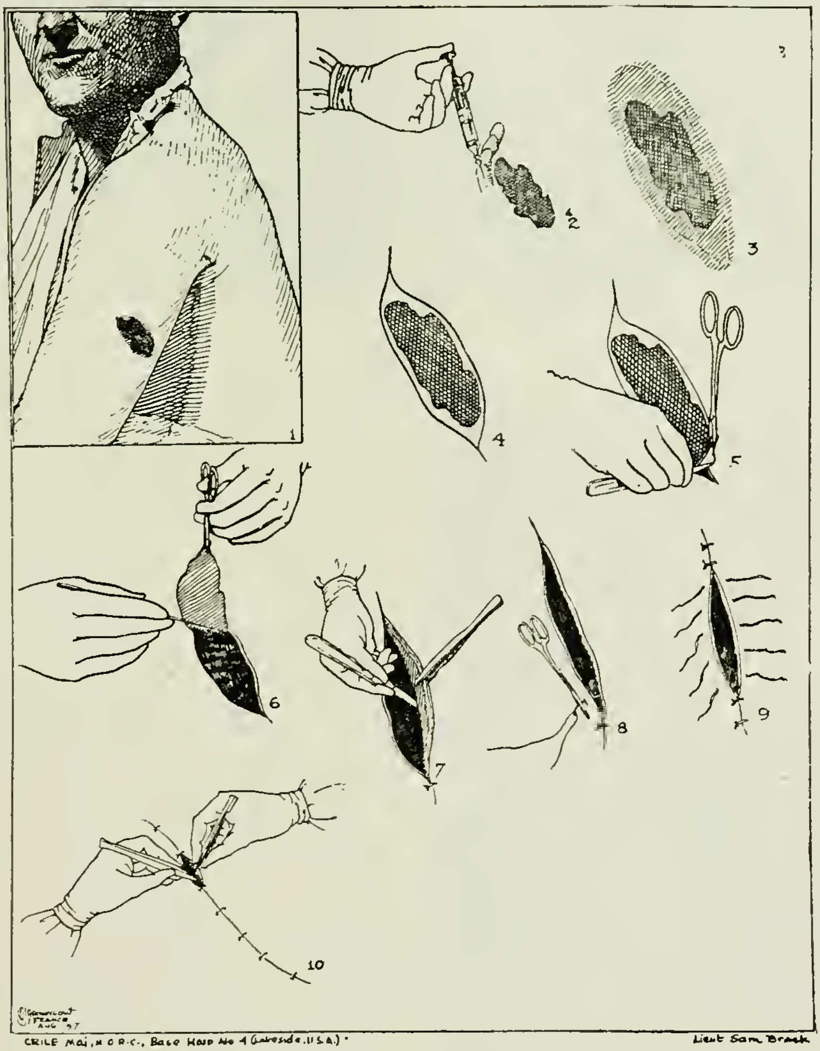


Fig. 1. High explosive wound. Skin prepared with iodin and alcohol.

Fig. 2. Injecting novocain, 1:200.

Fig. 3. An area 5 centimeters in width is blocked.

Fig. 4. In order to obtain an elliptical wound, it is often necessary to begin the line of excision farther away from the wound than the condition of the tissue itself demands.

Figs. 5 and 6. The excision of the wound *en masse.*

Fig. 7. It is advisable in all cases to make skin flaps, as this procedure lessens tension and tends to prevent inversion of skin edges.

Fig. 8. Silkworm-gut suture material is employed. The end sutures are placed about 2 centimeters from the beginning and end of the incision, which procedure prevents puckering at the ends.

Fig. 9. Sutures are placed loosely at 2 centimeters intervals or wider, and about 3 centimeters from the margin of wound. The dead space is eliminated by including deeper tissues.

Fig. 10. Skin edges everted. Alcohol dressing.

Fig. 11. Shrapnel wound after 6 days' treatment, and 6 days after excision and suture.

Fig. 12. High explosive wound after 4 days' treatment, and 7 days after excision and suture.

Fig. 13. High explosive wound, after 5 days' treatment, and 6 days after excision and suture.
Fig. 14. High explosive wounds after 6 days' treatment, and 4 days after excision and suture.

times daily. The superficial infected wounds usually cleared up under this treatment in two to three days. Sixty-five per cent. alcohol dressings were then substituted and applied twice daily for two to three days. In many instances where contamination had not progressed to infection, alcohol dressings were employed from the beginning. Whenever feasible, the wounds were exposed to the rays of the sun for an hour daily. When the granulating tissue had assumed a healthy appearance, and there was no further discharge, which was usually the case within four to six days, excision and suture was done. Most of the wounds were excised *en masse* by block dissection.

It is not advisable to remove sutures before the eighth day in the majority of cases, and even then alternating sutures in many wounds.

During the months of June, July, August, September and October, 1917, 294 wounds were excised and sutured under local anesthesia. Of these primary union resulted in over 95 per cent.

Note.—I am indebted to Major George W. Crile, and Major William E. Lower, M. R. C., for suggestions.

PATHOLOGICAL PULMONARY CHANGES FOLLOWING INTRATRACHEAL ANESTHESIA FOR EXPERIMENTAL LUNG SURGERY . HISTORICAL CONSIDERATIONS . PULMONARY CHANGES FOUND BY OTHER OBSERVERS . DANGERS OF RESECTION OF THE LUNGS . PNEUMOTHORAX . INTRATRACHEAL INSUFFLATION . RESULTS OF EXPERIMENTAL PNEUMECTOMIES . CASE REPORTS . SUMMARY OF THE NINETEEN EXPERIMENTAL CASES . RECOVERIES . PRECAUTIONS . SOME SURGICAL AND ANESTHETIC POINTERS .

CONRAD GEORG, JR., M. D. SURGICAL LABORATORY UNIV MICH. ANN ARBOR.

SURGEONS HAVE NOT FOUND the thoracic cavity as easy and safe of invasion as the abdominal. It was thought that differential pressure cabinets and intratracheal insufflation would obviate most of the difficulties of intrathoracic surgery but they have not. Despite the immense amount of experimental and clinical work along these lines much of importance, both to the surgeon and the anesthetist, remains to be revealed. These researches in the pathological pulmonary changes following intratracheal anesthesia for experimental lung surgery, as made in the Surgical Laboratory of the University of Michigan, by Conrad Georg, Jr., and his co-workers, and published in the Journal A. M. A., and the American Journal of Surgery, Anesthesia Supplement, are herewith reprinted because they are prone to occur in clinical experience as well as laboratory experiments.

Although much experimental work has been done upon the surgery of the lungs and some operations of this kind have been successfully performed upon man, writes Georg, it still continues to be a dangerous field for surgery and some facts may yet be discovered experimentally which will prove of practical value in performing these operations upon man.

The experimental work which forms the basis of this paper was done by means of Meltzer's insufflation apparatus in which the pressure was furnished at first by the operation of a pair of bellows and later by means of compressed air.

HISTORICAL CONSIDERATIONS.

THE USE OF intratracheal insufflation to maintain an adequate pressure of air while operating upon the thoracic organs has been known since the time of Vesalius who in 1560 discovered that he could prolong the life of an animal after opening its thorax to study the motions of the heart by blowing through a tube introduced into the trachea.

Robert Hook on October 29, 1667, delivered an address before the Royal Philosophical Society in which he showed that the respiratory movements were simply for the purpose of bringing about a supply of fresh air to the lungs. He experimented upon a dog, opened its chest and kept it alive by blowing air into its lungs by means of bellows occasionally permitting the lungs to collapse and then distending them. Upon ceasing the blast the dog would fall into dying convulsive fits but revived again upon inflating the lungs.

During the latter part of the eighteenth century the bellows were generally used in England to resuscitate people who had been drowned and it was then known that there was danger of over distention of the lungs if the blast was made too vigorously.

Desault in 1790 introduced a rubber catheter into the trachea in order to relieve difficult breathing due to stricture of the larynx. In 1827 Le Roy pointed out that if a very high pressure were maintained with the bellows it might result in emphysema and death. The use of an intralaryngeal tube for croup was described by Bouchut in 1857-58, and O'Dwyer of New York described his intubation apparatus for diphtheria in 1885. In 1887 Fell of Albany described his method of artificial repiration by means of a pair of bellows and a tracheotomy tube. Francois Frank brought out two forms of positive pressure apparatus in 1896. In the same year Quenu and Longuet made a positive pressure apparatus and Tuffier advocated insufflation in operations upon the pleural cavity. This was tested experimentally upon animals and clinically in operations upon man in the hospitals of Paris. In Quenu's apparatus the head was placed in a chamber which resembled a diver's helmet. Compressed air and chloroform were used for the insufflation. In 1900 Matas employed the Fell-O'Dwyer method in intrathoracic surgery.

PULMONARY CHANGES FOUND BY OTHER OBSERVERS.

IN 1904 THE ATTENTION of experimenters in intrathoracic surgery was somewhat diverted from the use of positive pressure by the researches of Sauerbruch of Germany. The latter, following the advice of Mikulicz had done considerable experimentation with the object of overcoming the ill effects of pneumothorax during and after intrathoracic operations by the use of negative pressure. Woillez in 1875 had already invented his *Spirophore* which made use of negative pressure. Sauerbruch enlarged the *spirophore* at first to the size of a small cabinet just large enough for operating upon dogs and later on into the form of a cabinet large enough for operations upon man. As a result of much experimentation upon dogs Sauerbruch concluded that positive pressure produces numerous disturbances in the normal circulation in the lungs. Brauer (1904) and Seidel (1907), however, found that the changes were so slight as to be of no importance when only enough positive pressure is used to prevent pneumothorax. Cloetta (1910-1913) made some experiments with a special lung plethsmograph to determine the effects of positive and negative pressure upon the circulation in the lungs. He resected the chest wall and placed the lungs in a glass plethysmograph and stopped the respiratory movements by the use of curare. In this manner he proved that if the lung is distended to the same degree exactly by positive and negative pressure, one-third less pressure is required with the negative than with the positive or if the same amount of pressure is used in each case the lung will be more distended with negative pressure. Furthermore, he showed that with the same distention of the lungs, the aortic pressure falls more with positive pressure than negative and that the pressure in the pulmonary artery rises higher with positive pressure and there is an increased diastolic pressure in the right ventricle. A high degree of positive pressure results in compression of the lung capillaries. Experience has shown that a slight degree of positive pressure is not dangerous but high or long continued pressure may result in serious reflex disturbances in the lungs and deleterious effects upon the circulation, depending upon the reserve power of the right ventricle.

All animal experiments seem to show that total extirpation of one lung has a higher mortality with positive pressure than negative, because the pressure of air in the empty pleural cavity which cannot be entirely driven out prevents the collapse of the chest wall and change in position of the diaphragm, mediastinum and sound lung which is necessary for recovery. These facts have been well established by experimental evidence. Block, Gluck and Schmid made researches of this kind in 1881. Biondi in 1884, obtained four recoveries in fifteen operations. Mayer of Brussels reported two recoveries in seventeen total pneumectomies on dogs. Janeway removed one entire lung in five dogs with recovery, using positive pressure. Sauerbruch and Haecker, using positive pressure, lost thirty-four dogs out of thirty-eight in their first series of experiments. The extirpation was done through one intercostal incision. Eleven died of leakage from the bronchial stump, five from primary infection at the time of operation and eighteen from the pressure resulting from pleural exudate. In the second series of twelve dogs, eight died.

Robinson in 1908, reported a series of thirty thoracic operations on dogs by means of his positive pressure apparatus. In this series there were nine deaths and twenty-one recoveries. There were nine simple pleurotomies with two deaths and seven recoveries. One experiment was merely the application of the positive pressure without opening the thorax to demonstrate whether the method of anesthesia was dangerous in itself and this ended in recovery. There were nineteen excisions of the lung with seven deaths and twelve recoveries. Another experiment consisted in clamping and releasing the lower lobe of the lung and ended in recovery.

Willy Meyer under a combination of positive and negative pressure performed twenty-one total excisions of the lung with seventeen recoveries. Removal of one or more lobes was done six times with five recoveries. In a series of twenty-four cases there were twenty-two recoveries. At one time twelve dogs were operated upon without a single death. Giertz operating with positive and negative pressure, used a flap of the fascia lata for covering the wound in the lung after resection and had eight recoveries out of ten operations upon large dogs. In rabbits there were no deaths. Robinson and Sauerbruch in 1910 found they got better results by resecting four ribs when a complete extirpation of one lung is done than if the operation is done through an intercostal space. The collapse of the chest wall thus obtained helps to close off the space left in the chest cavity thus tending to prevent pneumothorax but if a larger resection is done the animal may die because the operated chest wall offers no resistance to pressure within the sound lung, as a result of which the thin mediastinum is apt to rupture, resulting in a double pneumothorax.

Schlesinger in 1911, using Meltzer's apparatus, did seventeen total pneumectomies with five recoveries. He generally found air in the pleural cavity postmortem in the operated side and sometimes in the unoperated side. Kawamura (1914) has successfully removed the entire left lung of dogs and in a few instances a part of the right lung also at a second operation. This was done by means of Shoemaker's positive pressure apparatus.

So far there have been sixteen cases of pneumectomy in man with eight deaths. Helferich, 1898, removed the middle and lower lobes of the right lung in man for sarcoma of the chest wall. Heidenhein in 1901 removed the left lower lobe of the lung for bronchiectasis and this was followed by a fistula. Stretton in 1906, successfully resected the upper lobe of the right lung for tuberculosis. Robinson in 1912, removed the lower lobe of the left lung for bronchiectasis. Kümmell in 1911, removed the entire right lung from a man, 48 years old, for carcinoma. This patient died on the sixth day from edema of the lungs and tracheal rattling. Postmortem showed necrosis of the lung stump on account of the fact that the bronchi and vessels of the lung were clamped with forceps.

DANGERS OF RESECTION OF THE LUNGS.

RESECTION OF THE LUNG is a very dangerous operation both on dogs and on the human being on account of the danger of pneumothorax and of the difficulty of making a hermetic closure of the bronchus and lung. Infection may also take place from the outside if the wound gapes open or drainage is used. Another source of infection of the lungs and bronchi may result from the presence of germs in the nose and throat which are driven inward by the insufflation apparatus. This is particularly true of dogs which are affected with distemper as may be seen from my experiments. Distemper is a nasopharyngeal catarrh occuring in dogs and caused, as Ferry proved, by the bacillus bronchisepticus. The disease is accompanied by respiratory, abdominal and nervous symptoms and often results in death. It is the common presence of this infection in dogs together with their necessary confinement in laboratories, when accustomed to an out-door life, which lowers their resistance to surgical operations and makes the results of experimental surgery much less favorable than the same operations upon man.

The statistics of experiments in lung surgery with positive and negative pressure show much better results with the latter because it produces conditions closely resembling the physiological. Robinson and Sauerbruch in 1909 concluded that the space left behind after doing intrathoracic operations under negative pressure diminishes rapidly but that this is not the case in such operations done under positive pressure as most of the dogs died from the formation of an exudate. I found similar results in my experiments. Kawamura, however found no exudate after his operations although he used Shoemaker's positive pressure apparatus. The great difficulty in these operations is to prevent pneumothorax and infection, both from the interior of the lung and the outside, without causing any damage to the histologic structure and circulation in the lungs.

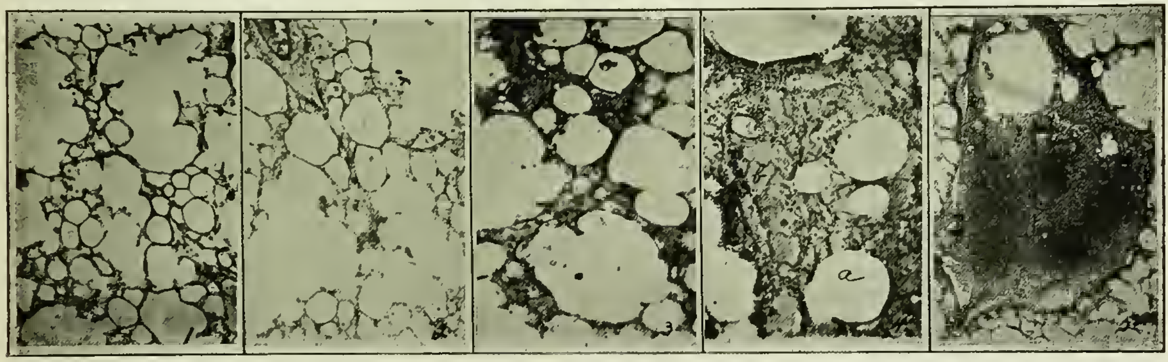
Dogs are especially unfavorable subjects for these operations on account of the shock which results from exposure and loss of body temperature, their inability to stand pneumothorax well and their low resistance to infection in the pleural cavity. They bear peritoneal infection very much better as can be seen from the numerous successful abdominal operations that have been performed upon them. The pleuritic exudate which generally forms after these operations acts unfavorably because the normal circulation is important for the elmination of germs from the pleural cavity as was proved by Nötzel's experiments. This fluid is absorbed very much more slowly by the inflamed than by healthy pleura. Grober in 1901, thought that this slow absorption was due to the fact that the stomata are closed by fibrin and that the endothelium is damaged by the inflammation. The same is true of the absorption of air in pneumothrax. Dorpat in 1893, showed that 78 cubic centimeters of air was absorbed in twenty-four hours by a dog weighing 11.7 kilograms, but that it took four days to absorb 35 cubic centimeters of air when the pleura is inflamed.

The exudate which forms after a thoractomy causes compression of the lung which has a bad effect upon its circulation and function. Secondary infection of the compressed lung may result in the formation of areas of pneumonia as may be seen from my experiments. Drainage is apt to be allowed by pneumothorax and secondary infection of the pleura. In Experiment VI where the entire left lung was removed, the entire pleural cavity on that side was filled with a thick fibrinous coagulated exudate. This was nature's effort to overcome the bad effects of pneumothorax. Tiegel invented a drain which allows fluids to escape, but prevents the entrance of air or fluid into the pleural cavity. In the case of wounds of the lung in man, pneumothorax can be prevented by the use of Tiegel's drain and emphysema may be treated by aspiration according to Bier's method.

PNEUMOTHORAX.

THE PECULIAR ANATOMY of the dog's thorax gives it very little resistance to pneumothorax. In this respect it differs from the rabbit very much. The thorax in man offers considerable resistance to pneumothorax as in only about 5 per cent. of intrathoracic operations does it become necessary to use any apparatus to prevent pneumothorax. Surgeons have known this in the past because numerous operations have been done for empyema and lung abscess without the use of any differential pressure apparatus. In chronic cases of empyema, owing to the formation of firm adhesions between the lung and parietal pleura and because of the fixed position of the mediastinum it is possible to resect portions of all the ribs of one side without danger to life. Children can usually stand extensive resections of the chest wall and lung because their relatively soft chest wall can readily contract and the diaphragm lies high so that the space which is left behind soon becomes closed off. Conditions in the rabbit are similar.

In the dog these conditions are entirely different as the animal will die in a few minutes if a wide opening is made in the chest without the use of differential pressure. In this animal the mediastinum is a wide, very delicate and transparent membrane and there is a mediastinal band extending from the neck to the diaphragm. On this account it is unable to resist any marked changes of pressure within the thorax without injury to the heart and pulmonary circulation. The thickness and rigidity of the mediastinum in rabbits enable them to stand pneumothorax for a long time. Although the operated lung and heart follow the mediastinum into the normal side of the thorax during inspiration, still the mediastinum gets into its normal position during expiration. In the case of the dog the mediastinum is so loose and delicate that it flutters up into the wound and often becomes perforated thus allowing air to get into the sound half of the thorax resulting in double pneumothorax. In consequence of this the pressure of the external air in the opened side of the thorax exercises dangerous compression upon the normal lung which is unable to drive the air out entirely even with the help of the diaphragm and the accessory muscles of respiration. Le Play and Mantoux showed that by induced pneumothorax they could render all but one-sixth of a dog's lungs atelectatic without causing death.

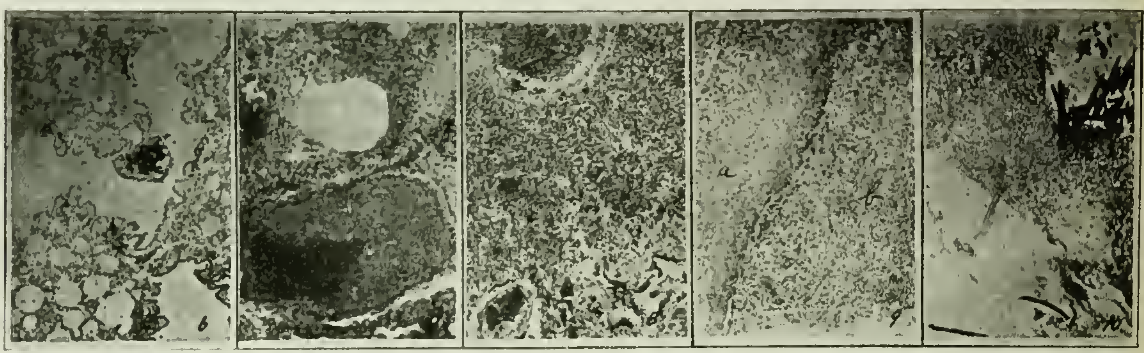


Case IX.—Photomicrographs of sections of (1) unoperated lung, acute emphysema; (2) unoperated lung, acute emphysema, ruptured alveolar walls, congestion, areas of hemorrhage; (3) operated lung, *a*, emphysema, *b*, hemorrhage into alveoli, congestion and edema; (4) operated lung, acute emphysema, rupture of alveolar walls, congestion and edema; (5) operated lung, acute emphysema with rupture of alveolar walls.

INTRATRACHEAL INSUFFLATION.

In 1910, MELTZER introduced his method of intratracheal insufflation for the purpose of maintaining a positive pressure within the lungs in order to prevent pneumothorax during intrathoracic operations. The technic of this method was established by a long series of experiments upon dogs. · A soft rubber catheter is introduced through the larynx into the trachea after the patient has been thoroughly anesthetized. The lower jaw is propped widely open and the tongue is drawn forward until the epiglottis is recognized. The latter is then drawn forward with a long pair of curved forceps and the catheter passed along the forefinger until it enters into the larynx. The catheter should be provided with a terminal opening instead of a lateral one. After the catheter is introduced as far as it will go it is deeply in the right bronchus and it should be slightly withdrawn (about 5 to 6 centimeters) and secured in position so that it will not slip out of place. It should be determined whether the catheter is in the trachea or esophagus, as acute dilatation of the stomach will result if it is in the latter. This will prove fatal unless the air is removed from the stomach by disconnecting the catheter with the appartus and making pressure over the stomach until the distention is relieved.

After the catheter is attached to the insufflation apparatus, ether mixed with air is blown into the lungs either by pressure upon a pair of bellows or by a connection with a compressed air apparatus. This apparatus is connected with a mercury safety valve which is set at 30 millimeters so that if the pressure in the apparatus exceeds that point the excess of air will bubble off through the mercury. The average pressure which should be maintained for intrathoracic operations upon dogs is 18 to 25 millimeters. The pressure in operations upon man may be raised to 35 to 40 millimeters. Meltzer considers it safe at any point below 50 to 60 millimeters. There is also a valve attachment to the apparatus for the purpose of releasing the pressure in the lungs about six times a minute for a period of two seconds at a time to prevent shock and damage to the lungs. This also relieves the obstruction to the flow of venous blood to the right auricle from the great veins of the chest and abdomen. The size of the French catheter varies from 18 to 24 or with a diameter of 8 millimeters and a lumen of 4 millimeters according to the size of the animal.



Case XIV.—Photomicrographs of sections of (6) unoperated lung, some emphysema, anthracosis, marked dilatation of bronchioles; (7) unoperated lung emphysema, congestion and anthracosis. Case XV.—Photomicrographs of sections of (8) operated lung, nearly complete atelectasis, partial collapse of smaller bronchi, congestion; (9) operated lung, *a*, thick fibrino-purulent pleural exudate, *b*, collapsed lung; (10) operated lung, *a*, purulent of pleural exudate, *b*,embodied stitches.

This method of anesthesia will not be accompanied by asphyxia if the catheter is of the proper size and the blood is well aerated. My experiments show that it does cause some damage to the alveoli of the lung. Severe shock and reflex disturbances are likely to follow this method of anesthesia if the pressure within the lung is maintained at a point higher than 25 to 30 millimeters.

Sauerbruch proved by animal experimentation that the breathing capacity can be reduced to one-tenth of normal without endangering the oxygen content of the blood. Spontaneous breathing should take place at all times during the anesthesia.

Seidel showed that there is a fall in blood pressure upon interrupting the pressure in the lungs. This fall in blood pressure was equalized so that it returned to normal before the cessation of the interruption. The pulse curve also showed some irregularity.

Robinson reported in 1913 that intratracheal anesthesia had been used in 1,402 cases with seven deaths. It is very useful in operations about the mouth, nose and throat as well as those within the chest, because blood and mucus cannot enter the glottis.

RESULTS OF EXPERIMENTAL PNEUMECTOMIES.

A SERIES OF PNEUMECTOMIES were performed upon dogs at the Surgical Laboratory of the University of Michigan, using Meltzer's apparatus for intratracheal insufflation in order to determine whether there are any serious dangers connected with this method of anesthesia. The technic which was used in these operations was as follows: The field of operation was shaved on the day before the time set for operation. The dogs were given nothing to eat for twenty-four hours previous to the operation. A hypodermic of morphin gr. $\frac{1}{4}$ and atropin gr. $\frac{1}{150}$ was given one-half an hour before the beginning of the anesthesia. This dose was doubled in the case of the large sized dogs. After placing the animal upon the table the field of operation was scrubbed with a sterile brush and soap followed by sterile water, acetic acid and alcohol then sterile water again followed by a solution of bichloride of mercury 1/1000.

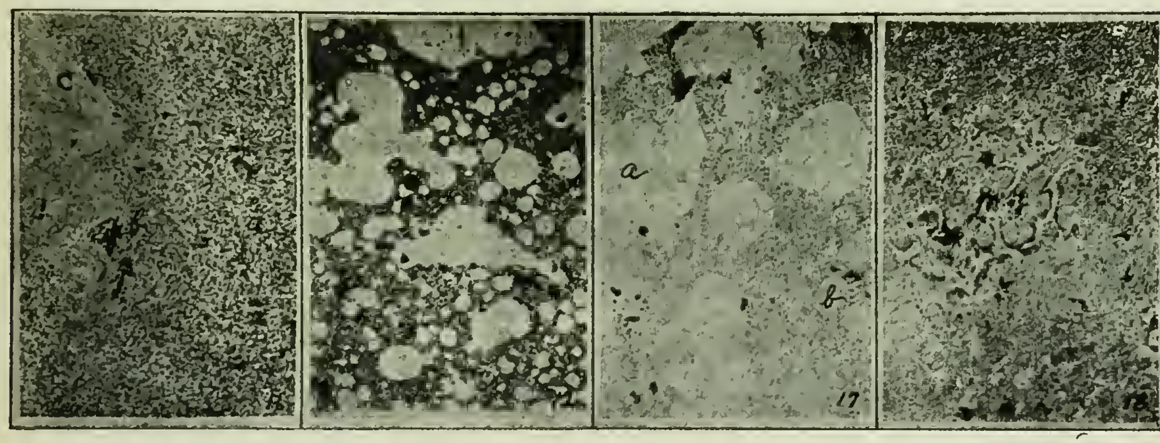
After the animal was completely anesthetized the catheter was introduced through the larynx into the trachea until it met an obstruction, then

dam was applied over the tube and sutured into position. Aseptic dressings applied.

May 20—Dog jumped out of box, dyspnea present.

May 21.—Dog died. Edema of all the tissues and fluid found in both pleural cavities. Tube was blocked with fibrin.

"Postmortem examination shows acute emphysema, rupture of the alveolar walls, congestion and edema. The large tear appears to be postmortem," Warthin. I had inserted the catheter into the trachea and insufflated with the bellows to see how much pressure the lungs would stand without rupturing. No rupture was noticed on the surface of the lung. A moderate distention, therefore, is all the lungs will stand during insufflation without the lungs being so badly damaged internally that the patient cannot recover.



Case XVII.—Photomicrographs of sections of lungs, (11) operated, *a*, atelectasis, *b*, anthracosis, *c*, scar tissue; (12) operated lung, some emphysematous areas and anthracosis. Case XIX.—Photomicrographs of sections of (17) operated lung, *a*, emphysema, *b*, hemorrhagic area; (18) atelectasis, collapse of bronchi, congestion, hemorrhage and anthracosis.

it was withdrawn about five centimeters and attached to the insufflation apparatus. The same aseptic technic was followed in these operations as is customary in any major operation upon man in a modern hospital.

The following are reports of those experiments of which the microphotographs of pathological pulmonary changes are presented:

CASE REPORTS.

Case IX.—Operation: Resection of one lobe of left lung. Result: Death in two days.

May 19, 1914, 8 P. M.—Miss Davis gave anesthetic. The same aseptic precautions as in any hospital surgical operation. Towel clamps applied. End of intratracheal catheter cut off so that it had a terminal instead of a lateral opening. Incision in seventh intercostal space. The distention of the lung was good. ribs retracted with mouth gag, lung grasped with rubber protected clamps and one lobe removed. The bronchi were ligated cautery applied to wound and the lung carefully sutured. A drainage tube was introduced about two inches from the spine and only to edge of pleura. The air around the operated lung was aspirated with a small air pump and a rubber

Case XIV.—Operation: Resection of one lobe of left lung. Result: Recovery.

December 29, 1914, 8 P. M.—Dog weighs 19.8 kilograms or 44 pounds. A number 24 French soft rubber catheter was used for intubating the larynx and trachea, and the pressure kept at 25 to 30 millimeters.

Operation performed by Drs. Hayes and Cattermole under strict aseptic precautions. A strip of the fascia lata was used to cover up the wound in the lung.

December 30.—Dog stands up in cage, respirations 40, pulse rapid. Bowels have moved.

December 31.—Respirations 40, pulse 120-130; temperature 102.8 per rectum. Normal resonance on percussion over the entire lung.

January 1, 1915.—Respirations 40, pulse 130, temperature 102. Tympanitic resonance over entire left chest with crackling of subcutaneous tissues upon palpation. Normal resonance over right lung.

January 2.—Respirations 40, pulse 132 and temperature 101.5°. The dog gradually improved, and recovered from the operation, became very active, and barked very loudly so that he could be heard all over the medical building.

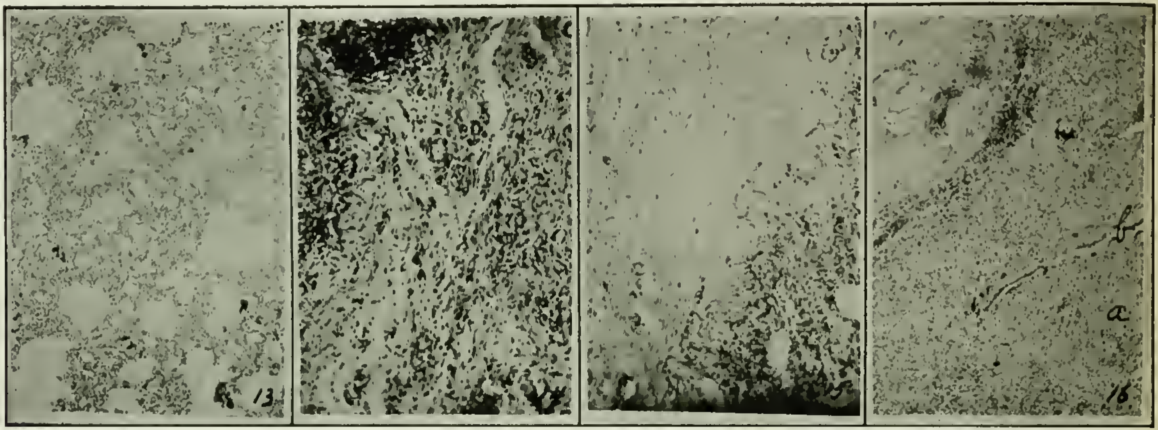
June 12.—Six months after operation the dog weighs 30 pounds or 13-7/10 kilos. This loss of weight may have been due to the confinement in the laboratory without exercise out of doors. The food was not as nourishing in character during the last month as it was during the rest of the year. Dog was killed with ether. There were numerous adhesions between the operated lung and the chest wall, also marked anthracosis of both lungs. The fascia lata was united with the pleura covering the lung. No fluid in either pleural cavity. The pathologic report from Dr. Weller upon the lungs is as follows:

"Unoperated lung, marked anthracosis, some emphysema, otherwise practically negative. Site of operation: a subacute purulent inflammation. Small abscess. Healing progressing rapidly about the abscess."

April 19, 1915.—Small female dog weighs 22½ pounds. Number 21 French catheter passed into the larynx and trachea after the dog was anesthetized. Aseptic operation performed by Drs. Hayes and Cattermole. Resection of one rib subperiosteally. One lobe of the lung was removed and wound carefully sutured after ligating the bronchioles and vessels. The lung wound was covered with a portion of the fascia lata. External wound closed and sealed with gauze and collodion.

April 20.—Dog doing well and shows no bad symptoms.

June 12, 1915.—Weight is 16½ pounds, or 7-3/10



Case XVIII.—Photomicrographs of sections of (13) unoperated lung, congestion, anthracosis, some alveoli overdistended; (14) operated lung, subacute purulent inflammation, organizing fibrino-purulent pleuritis; (15) operated lung, subacute purulent inflammation, organizing fibrino-purulent pleuritis; dense fibrous connective tissue covering lung tissue; (16) operated lung, *a*, atelectasis, *b*, collapsed bronchus, *c*, scar tissue following operation.

Case XVII.—Operation: Resection of one lobe of left lung. Result: Recovery.

April 9, 1915.—Black and white male mongrel weighs 50 pounds. Number 24 French catheter passed into larynx and trachea after the dog was anesthetized. One rib resected subperiosteally. Pressure 25 to 30 millimeters. Resection of middle lobe of left lung, under the same aseptic precautions as are used in any major operation in a modern hospital. Several bronchioles ligated with silk and lung wounded sutured with mattress stitches of silk and a strip of fascia lata sutured over it. There was no leakage of air after the lung suturing was complete. External wound sutured in layers and sealed with gauze and collodion.

April 10.—Respirations 30, dog doing well.

June 12.—Two months after operation, dog weighs 32½ pounds or 14-7/10 kilos; looks emaciated probably because of poor food and confinement. Killed with ether. Some small adhesions between the operated lung and the chest wall and between neighboring lobes of the lung. Fascia lata united over the lung.

Pathologic report from Dr. Weller: "Unoperated lung: Practically normal. Some emphysematous areas. Seat of operation: Areas of atelectasis. Sutures still remain. No positive traces of fascia lata. Inflammatory process practically healed."

Case XVIII.—Operation: Resection of one lobe of left lung. Result: Recovery.

kilos, emaciated in appearance, probably from confinement and inferior character of the food during the last month. Wound healed with very little scar tissue. Killed with ether and lungs removed.

Pathologic report Dr. Weller: "Unoperated lung; congestion, anthracosis, some alveoli appear over-distended. Operated lung: Subacute purulent inflammation. Embedded sutures. Organizing fibrino-purulent pleuritis."

SUMMARY OF THE NINETEEN EXPERIMENTAL CASES.

Case I. Pneumectomy. Recovery.

Case II. Pneumectomy. Death, 5th day. Empyema.

Case III. Pneumectomy. Death, 2nd day. Pneumothorax.

Case IV. Pneumectomy. Death, 30th day. Empyema.

Case V. Pneumectomy. Death, 3rd day. Pneumothorax.

Case VI. Pneumectomy. Death, 6th day. Penumothorax.

Case VII. Pneumectomy. Death, on table. Paralysis of glottis.

Case VIII. Pneumectomy. Death, 2nd day. Pneumothorax.

Case IX. Pneumectomy. Death, 2nd day. Overpressure.

Case X. Pneumectomy. Death, on table. Pneumothorax.
Case XI. Pneumectomy. Death, 7th day. Overpressure empyema.
Case XII. Pneumectomy. Death, 2nd day. Overpressure and distemper.
Case XIII. Pneumectomy. Death, 3rd day. Distemper.
Case XIV. Pneumectomy. Recovery.
Case XV. Pneumectomy. Death, 6th day. Empyema and distemper.
Case XVI. Application of insufflation. Recovery.
Case XVII. Pneumectomy. Recovery.
Case XVIII. Pneumectomy. Recovery.
Case XIX. Pneumectomy. Death, 4th day. Overpressure and distemper.

There were eighteen lung operations and four recoveries.

RECOVERIES.

MANY OF THESE EXPERIMENTS were failures because it was necessary to develop the technic by careful experimentation before successful surgery upon the lung could be done. An examination of these results will enable one to form an adequate idea of the difficulties that must be overcome in performing operations upon the lungs. As the majority of the dogs operated upon were afflicted with canine distemper the mortality is necessarily much higher than it would have been if healthy animals could have been obtained for this work. A careful study of these results warrants the following conclusions:

Intratracheal insufflation was not without harmful effects upon the lungs even in those dogs who recovered. Interstitial emphysema and over distention of some of the alveoli of the lung were shown microscopically. These changes were much more marked in those animals that died than in those that recovered and consisted of large hemorrhagic areas with tearing of the walls of the alveoli. Insufflation also has a very harmful effect upon the circulation in the lungs as is shown by the intense congestion and atelectasis found microscopically. In applying this method of anesthesia to intrathoracic operations upon the human being great care must be exercised in order to have the pressure high enough to prevent pneumothorax and still not so high as to cause serious damage to the circulation in the lungs or to cause a severe degree of interstitial emphysema.

The transplantation of a strip of fascia lata upon a wound of the lung gives an added protection to it from infection. Preliminary ligation of the bronchi and careful suture of the lung tissue must always be done. After the suturing is complete careful search must be made for the escape of air from the lung wound by moistening it with salt solution. If any air escapes the wound must be reenforced by additional suturing. For intratracheal insufflation a catheter of number 18 to 24 French should be used and the pressure should be maintained at 20 to 25 millimeters of mercury.

I desire to thank all those who assisted me in these experiments and especially Dr. Warthin for the examination of the pathologic material and the preparation of the photomicrographs which form a part of this article.

PHARMACOLOGY AND PHYSIO-PATHOLOGY OF LOCAL ANESTHETICS . APOTHESIN—A NEW ANESTHETIC . CLINICAL EXPERIENCES . PERSONAL STUDIES . DISADVANTAGES OF CHLORETONE . A PHARMACOLOGICAL AND THERAPEUTIC STUDY OF BENZYL ALCOHOL AS A LOCAL ANESTHETIC . INTRODUCTION . PHYSICAL AND CHEMICAL PROPERTIES . PHARMACOLOGICAL ACTION . ANESTHETIC EFFECT . ACTION ON THE CIRCULATION, RESPIRATION AND CENTRAL NERVOUS SYSTEM . TOXICOLOGY . FATE IN THE BODY . EFFECT ON TISSUES . DURATION OF THE ANESTHESIA . CLINICAL DATA . DISCUSSION . SUMMARY OF LABORATORY AND CLINICAL RESULTS .

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IN A VERY PROPER spirit of investigation, Carroll W. Allen of New Orleans, La., one of America's greatest authorities on local anesthesia, and a contributor to the Year-Book, 1915-16, shortly after the introduction of apothesin began its use in his clinics and conducted numerous experimental injections on himself to test-out, to his own satisfaction, the worth of the new analgesic. In publishing his data in the New Orleans Medical and Surgical Journal, Allen suggests that:

It is with much pleasure that we note an effort on the part of our chemical manufacturers to provide us with drugs, the original products of their own laboratories and make us independent of foreign sources, which have so long been our only source of supply. Apothesin, recently presented in experimental quantities by Parke Davis & Co., is a synthetic product of their laboratory. Chemically, it is the cinnamic ester of gammadiethylamino propyl alcohol hydrochlorid. Apothesin occurs in the form of small snow-white crystals, having a melting point of approximately 137° C. It is easily soluble in alcohol; very soluble in water; and slightly soluble in acetone and ether.

CLINICAL EXPERIENCE.

DURING A CLINICAL EXPERIENCE of several months, I have been very favorably impressed with the anesthetic properties of this product and have performed hernia, hemorrhoid, fistula, varicocele, circumcision and plastic operations. I have uniformly used a ½ per cent. solution in 4 per cent. sodium chlorid with five drops of adrenalin chlorid solution, 1 to 1,000 to each ounce. The anesthesia has been complete in all cases and has invariably lasted in excess of an hour No immediate or late irritating effect was noted and the wounds healed as well as after the use of any other anesthetic solution. *No toxic or other unpleasant immediate or after-effects were noted, although large quantities were purposely used to determine this point; as much as four ounces in one case, which represented nearly ten grains of the drug.* This limited experience, with the absence of other data, is not sufficient to give it its proper place among local anesthetic agents. Data regarding its toxicity are not obtainable, but from my experience it must be very low. In this connection, the manufacturers state that its toxicity is not greater than that of novocain and considerably less than that of other anesthetics commonly employed.

PERSONAL STUDIES.

THE FOLLOWING ARE the results of injections made upon myself in studying its action. The preparation experimented with was in liquid form put up with a saturated solution of chloretone for purposes of preservation, which I believe is a mistake, as noted later. The solution was first boiled for ten minutes. Intradermal wheals were made in my skin at various points, using for each injection one cc. of solution.

1. One per cent. of apothesin, injection 9:55 p. m., slight negligible burning if injected too rapidly, which immediately subsided; no sensation if slowly injected. Immediate anesthesia. Within about ten minutes slightly pale area had developed around wheal and center became slightly pink. After fifteen to twenty minutes slight itching sensation; 10:30 p. m. pink center has become more marked; 11:10 anesthesia still complete; 11:25, returning sensation; 11:55, nearly normal sensation; 12:30, not yet quite normal. Complete anesthesia for one hour and fifteen minutes. Pink center to wheal still persists, with a very slight suggestion of infiltration in surrounding tissues.

2. One per cent. apothesin, five drops of adrenalin, 1 to 1,000 to the ounce, injection 10:02, results similar to last injection, except that pale area surrounding wheal was slightly more marked, with pink center more pronounced; 12:15, anesthesia still complete; 12:30, returning sensation. Complete anesthesia one hour and fifteen minutes. Subsequent appearance of area same as with 1 per cent. without the adrenalin.

3. One-half per cent. apothesin, sodium chlorid 4 per cent.; injection 10:07, no sensation during injection. Immediate anesthesia. Pink center and pale surrounding area as with other injections; 10:35, complete anesthesia; 10:40, returning sensation; 10:45, near normal; 11:00 o'clock normal. Thirty minutes complete anesthesia.

4. One-half per cent. of apothesin, adrenalin solution 1 to 1,000, five drops to the ounce. Injection 11:00 o'clock. Immediate anesthesia. Appearance same as above. Forty-five minutes complete anesthesia.

5. One-half per cent. apothesin, sodium chlorid 4 per cent., adrenalin solution 1 to 1,000, five drops to the ounce. Injection 10:13; 11:30, complete anesthesia; 11:37, returning sensation; 11:50, nearly normal. Complete anesthesia one hour and fifteen minutes. Appearance of injected area same as above.

6. One-fourth per cent. apothesin. Injection 10:33. No sensation. Immediate anesthesia; 10:55, complete anesthesia; 11:05, returning sensation· 11:15, nearly normal; 11:28, normal. Pink center and pale surrounding area less marked than with the stronger solutions.

7. One-fourth per cent. apothesin, 4 per cent. sodium chlorid. Injection 10:38. No sensation; 11:15, complete anesthesia; 11:19, returning sensation; 11:35, nearly normal; 11:50, normal. Thirty-seven minutes complete anesthesia. After-appearance same as above.

8. One-fourth per cent. apothesin, adrenalin solution 1 to 1,000, five drops to ounce. Injection 11:00 o'clock; 11:40, complete anesthesia; 11:45, returning sensation. Forty minutes complete anesthesia. After-appearance same as above.

9. One-fourth per cent. apothesin, 4 per cent. sodium chlorid, adrenalin solution 1 to 1,000, five drops to ounce. Injection 11:13; 11:50, complete anesthesia; 12:00 o'clock, returning sensation; 12:35, nearly normal. Thirty-seven minutes complete anesthesia.

The next day, a slightly reddish punctate spot marks the site of the wheals. This is more marked in those in which the stronger solutions have been used and slightly more so where adrenalin had been added. Slight soreness and itching in all spots when manipulated, but not noticeable without manipulation. In the two 1 per cent. injections a very slight infiltration of the tissues noticeable. The frequent examination of the areas in which they were stuck by a needle every few minutes during the period of the examination should be considered in drawing conclusions from their appearance. The anesthesia in all cases was immediate and complete and disappeared very slowly. It was often longer than one-half hour from the time returning sensation was first noted until it appeared normal. The pink appearance in the center of the wheal in the case of the stronger solutions persisted for forty-eight hours, but no similar reaction had been noticed in the clinical use of the drug, although the wound had been closely watched. To determine the cause of this reaction two injections were made into my skin with solutions, prepared by tablets of the same drug which *did not contain chloretone. In each case there was no sensation during the injection and the central pink area and surrounding pale areola were less marked and disappeared after a few hours.* Otherwise, the resulting anesthesia and its duration were the same. The site of injection, if disturbed by manipulation, gave a slight itching sensation, otherwise it was not noticeable.

DISADVANTAGES OF CHLORETONE.

TO TEST THE EFFECT of chloretone when injected alone, I injected my forearm with ten minims of a saturated solution of chloretone, 8 per cent., the same strength with which the apothesin is put up; slight burning occurred if injected too rapidly. When tested with a point of a needle for anesthesia, it was found to be completely anesthetic only in the center of the wheal and wherever the needle was entered, a red punctate spot appeared immediately and remained permanently. Otherwise the wheal presented no change in appearance from the surrounding tissue. Anesthesia lasted about forty minutes only in the center; the periphery quickly returning to normal.

I am consequently forced to the conclusion that much of the after appearance of the injected areas in these experiments must be due to the presence of chloretone in the solution and accordingly suggest that this method of preparing the solution be changed, as it probably will, and a drug marketed in powder form, as is the case with other local anesthetics.

In conclusion, I wish to state that I believe this preparation has a decidedly useful future and should be given a fair and impartial trial. In my own observation it compares, at least in its anesthetic producing properties and its low degree of toxicity, very favorably with novocain.

IT IS FORTUNATE indeed that David I. Macht's researches on the benzyl esters should have lead him to the discovery of the powerful local anesthetic properties of benzyl alcohol. With a thoroughness that has characterized all his work in the Pharmacological Laboratory of Johns Hopkins University, and aided by a grant from the James Buchanan Brady Urological Institute, Macht at once began and soon completed an extended pharmacological and therapeutic study of benzyl alcohol as a local anesthetic. He published his researches in the Journal of Pharmacology and Experimental Therapeutics, April, 1918, and presented his further conclusions to the American Medical Association during the Atlantic City meeting, 1919. By way of introduction Macht details the steps by which he arrived at a consideration of benzyl alcohol, as follows:

IN A COMMUNICATION presented by title by the present author at the annual meeting of the Society for Pharmacology and Experimental Therapeutics held on December 27-28, 1917, it was shown that the chemical structure of the opium alkaloids bears a peculiar relation to their action on smooth muscle structures. In respect to their action on smooth muscle, the opium alkaloids can be sharply divided into two classes: the pyridin-phenanthrene group of which morphin is the principal representative on the one hand, and the benzyl-isoquinoline group of which papaverin is the principal representative, on the other. Members of the morphin group all tend to stimulate the contractions and heighten the tonus of smooth muscle while members of the papaverin group all tend to inhibit the contractions and lower or relax the tonus of the same. Furthermore, the author has shown that the above stimulating action of morphin and its relatives is to be ascribed to the pyridin portion of their molecules, while the inhibitory and tonus-lowering properties of papaverin and its related alkaloids are to be attributed primarily to the presence of the benzylic grouping in their molecules.[1]

In a communication delivered by the present author on February 2, 1918, at a regular meeting of the Society for Experimental Biology and Medicine held in New York, it was further pointed out that the above relationship between the chemical structure of the opium alkaloids and their action on smooth muscle led to the discovery of some unsuspected but important pharmacological and therapeutic properties of the benzyl esters. Inasmuch as the action of papaverin on smooth muscle was traced down by the author as being inherent in the benzyl portion of its molecule, a search was made for some simpler

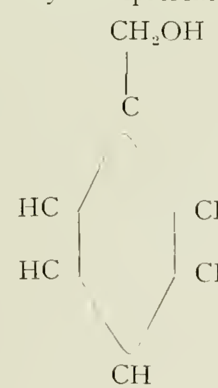
1. MACHT: Jour. of Pharmacol. and Exp. Therap., 1918, Vol. xi, 176.

compounds which would be non-toxic and non-narcotic but which, at the same time, might exhibit the characteristic tonus-lowering and inhibitory action of the benzyl radicle on smooth muscle. It was found that the simple and well-known organic esters, benzyl-benzoate and benzyl-actate, answered admirably this purpose. Experiments with these esters showed that they were comparatively non-toxic on the one hand, and when administered to animals gave all the papaverin effects as far as smooth muscle tissues or organs are concerned, on the other. The fate of these esters in the body was also investigated by the author and it was found that they were in large measure excreted as hippuric acid in the urine. This discovery of the peculiar pharmacological action of the benzyl esters on smooth muscle logically led to their practical application in medical therapeutics. The indications for their administration have been pointed out by the author before the Society for Experimental Biology and Medicine to be all cases in which there is an excessive peristalsis or contractions of smooth muscle structures or a spasmodic condition of the same. Further details in this connection are out of place in the present communication but may be found in the Proceedings of the above Society and full and complete data of the pharmacological and clinical experiments and experiences with the benzyl esters will be published soon in a future issue of this Journal.[2]

Inasmuch as the benzyl esters are transformed into hippuric acid in the living organism and inas much as such a transformation probably involves a transition from the esters through the alcoholic stage, the author naturally also made experiments with a view of determining the pharmacological actions of benzyl alcohol. It may be briefly stated that it was found that while benzyl alcohol can also in a measure produce the benzylic action on smooth muscle exhibited by the benzyl esters that for other reasons to be described later, this drug was not suitable as a therapeutic agent for that purpose. At the same time a new and very interesting property of benzyl alcohol was discovered in this connection. The author found, while incidentally tasting a minute quantity of this substance, that his tongue was completely anesthetized by it. On tasting the drug a slight irritation was first experienced which irritation was followed by a sensation of numbness, coolness and hardness, very much like the sensation experienced after application of a cocain solution to the tongue. This striking observation was immediately followed up by the author and experiments were undertaken to determine more accurately the action of benzyl alcohol on the sensory nerve endings and nerve conduction. It was soon found experimentally that this body was possessed of *powerful local anesthetic properties.* Experiments were then carried out for the purpose of determining its toxicity and having established the fact that benzyl alcohol is, in ordinary doses, but slightly toxic to laboratory animals, clinical tests were cautiously made with it. The results of experimental work and the clinical observations up to the present date have been so striking and conclusive in showing the anesthetic properties of benzyl alcohol on the one hand and its comparatively very low toxicity on the other, that it was deemed desirable to report the author's observations on the subject at once.

PHYSICAL AND CHEMICAL PROPERTIES.

BENZYL ALCOHOL or phenmethylol is a simple organic compound having the empirical formula C_7H_8O or $C_6H_5 \cdot CH_2OH$. Structurally it may be represented as follows:



It is found in nature in a free state (6 per

2. MACHT: Proceedings Soc. of Exp. Biol. and Med., Feb. 20, 1918.

cent.) in oil of jasmine and in the form of esters in Balsam Peru, Balsam Tolu and Storax. It is a clear liquid with a faint aromatic odor with a specific gravity of 1.0628 at 0°C and 1.0507 at 16.9°C. Its boiling point at a pressure of 760 mm. is 204.7° It is well to note this particularly in connection with the ease with which its solutions can be sterilized by boiling without destruction of the active principle. An even more fortunate provision of nature is the fact that while the benzyl esters, benzyl benzoate and benzyl acetate are practically insoluble, it was found by the chemist R. Meyer[3] that benzyl alcohol is soluble in water up to 4 per cent. at 17° C. This is especially important from a practical point of view because for clinical purposes the author has been able to confine himself to the use of solutions from 0.5 per cent. to 4 per cent. (and in most cases to a 1 per cent. solution) in physiological saline.

PHARMACOLOGICAL ACTION.

A COMPLETE PHARMACOLOGICAL study of benzyl alcohol including not only its anesthetic properties and toxicology but also its effect on various organs and on kidney function will be taken up in another paper. In the present communication the author will confine himself to a description and discussion of the anesthetic properties of this drug on the one hand, and its action on Bichat's *tripod of life*, namely, its effect on the circulation, respiration and the central nervous system on the other.

1. *Anesthetic effect.*

a. Action on the mucous membranes and the skin of the human being. The effect of benzyl alcohol on the sensory nerve terminals can be easily demonstrated by applying it to the mucous membranes of the lip, the tongue or the gums and even by applying the pure alcohol to the intact skin. On painting pure benzyl alcohol on the skin, a distinct local anesthetic effect can be observed. Pure phenmethylol applied to the tongue or the lip produces a primary irritating effect soon followed by complete anesthesia which may be felt as late as two hours after the application. The local anesthetic effect on the mucous membranes of the mouth can be distinctly demonstrated by the use of 1 per cent. solutions of the alcohol in water or saline and even by more dilute solutions. The anesthesia of the tongue produced by a 1 per cent. solution is perceptible as late as half an hour or longer after its application.

b. Anesthesia of frog's skin. The anesthetic effect of a 1 per cent. and even weaker solutions of benzyl alcohol on the sensory nerve terminals can be simply and beautifully demonstrated by means of a spinal cord reflex frog preparation. This method has been employed by Impens,[4] Issekutz,[5] Zorn,[6] Fromherz[7] and recently by Sollmann[8] and need not be described in detail. The method briefly consists in suspending a frog, the brain of which has been destroyed, and dipping its lower limbs in a weak acid solution. The irritating action of the acid on the sensory nerve terminals produces a reflex movement of self-defense consisting in withdrawing the limbs from the solution and rubbing them in an effort to remove the irritating agent. On immersing such a frog preparation in a 1 per cent. solution of benzyl alcohol for one minute, complete anesthesia of the skin is produced so that subsequent immersion in acid solutions produced no reflex response. Control experiments made with aqueous solutions of ethyl alcohol even three and four times as strong produced absolutely no anesthetic effect.

c. Anesthesia of the cornea. On instillation of 1 per cent. phenmethylol solution into the conjunctival sacs of rabbits and dogs, complete anesthesia of the cornea was produced as early as one to two minutes after the instillation. The cornea could be picked up with a forceps or

3. R. Meyer: Ber. deutsch. chem. Ges., 1881, Vol. xiv, 2394.

4. Impens: Deut. med. Woch., No. 29, 1905.
5. Issekutz: Arch. ges. Physiol., 1912, Vol. cxlv, 448.
6. Zorn: Zsft. Exp. Path. Ther., 1913, Vol. xii, 529.
7. Fromherz: Arch. f. Exp. Path. Pharm., 1914, Vol. lxxvi, 257.
8. Sollmann: Jour. of Pharmacol. and Exp. Therap., 1918, Vol. xi, 9.

probed with a sharp point without producing reflex winking of the eye. The above solutions were found to produce but slight irritation of the conjunctiva and the author found that this effect could be entirely counteracted by the addition of small amounts of epinephrin (1:20,000) to the anesthetic. In no case was the irritation greater than that produced by the same strength of cocain. Dilute solutions of the anesthetic such as used above produced no destructive changes in the cornea. On instillation of pure benzyl alcohol (100 per cent.) into the conjunctival sac of a rabbit, as might have been expected, some necrosis of the cornea followed but even in this case the eye recovered almost completely after the lapse of several weeks. Such a necrosis can, however, be produced by strong ethyl alcohol too.

d. Paralysis of sensory nerve fibers. The effect of benzyl alcohol solutions, 1 to 3 per cent., on the conduction of the sensory nerve fibers in frogs was studied by Sollmann's method.[9] It was found that benzyl alcohol in solutions of 1 per cent. produced complete blocking of sensory conduction after the lapse of a few minutes.

The conductive power of the sensory nerves in the sciatic of dogs was studied by Dixon's method.[10] It was found after placing a pledget of gauze soaked with a 1 per cent. solution of benzyl alcohol in saline on the dissected sciatic nerve of a dog, that stimulation of the nerve peripherally to the block five minutes after the application of the drug produced no change in the blood pressure curve, thus showing that sensory conduction has been paralyzed.

e. Paralysis of motor fibers. After application of a 1 per cent. solution of benzyl alcohol to the sciatic nerve of frogs, it was found that downward conduction was also paralyzed after the lapse of five minutes. The same effect was produced in the sciatic of a dog but only after using stronger solutions (4 per cent.) and applying them for from five to ten minutes.

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9. SOLLMANN: Jour. of Pharmacol. and Exp. Therap., 1918, Vol. xi, 1.

10. DIXON: Jour. of Physiol., 1904, Vol. xxxii, 87.

2. *Action on the circulation, respiration and central nervous system.*

a. Circulation. The effect of therapeutic doses and of even much larger doses of benzyl alcohol administered in the form of aqueous solutions 1 to 4 per cent., manifests itself almost exclusively on the blood vessels. Benzyl alcohol in this respect acts very much the same as the benzyl esters, benzyl acetate and benzyl benzoate, producing a vasodilatation through a direct action on the muscle fibers of the vessel walls. On injection even of large quantities 5 cc. to 10 cc. per kilo of 1 per cent. solution intravenously in dogs and rabbits, there is a fall in pressure due to this peripheral vasodilatation but not to any depression of the vasomotor center. Further injections of the drug produced no further lowering of blood pressure. The heart action is unimpaired and the vasomotor center is not affected until toxic doses of the drug are used, a fact which will be discussed under the heading toxicology (Fig. 1).

b. Respiration. Therapeutic doses and even much larger quantities of 1 per cent. solution of benzyl alcohol injected intravenously into rabbits and dogs as high as 5 cc. to 10 cc. and even 15 cc. per kilo weight of the animal, produced no appreciable change in the respiration. Indeed after the injection of small quantities of the drug there may be a primary stimulation of the respiratory center. On pushing the drug, however, to its toxic limit, the respiration begins to fail and death of the animal, after fatal doses of benzyl alcohol, occurs through paralysis of the respiratory center, the heart continuing to beat five minutes or more after the cessation of the respiratory movements (Fig. 1).

c. Central nervous system. Ordinary therapeutic doses of benzyl alcohol (5 to 10 cc. of 1 per cent. solution per kilo) injected intravenously in rabbits and dogs are followed by a sedative effect, the animal (not under general anesthesia) lying quietly and seeming somewhat narcotized. Indeed when 10 cc. of a 1 per cent. solution per kilo are injected into a dog or a rabbit, the skin of the animal may be incised without its offering any resistance or showing signs of pain. Still higher doses of benzyl alcohol injected into various animals show a deleterious effect on the central nervous system, smaller animals especially, often developing convulsions which are followed by paralysis of the respiratory center. This, however, is a toxic effect never produced by the doses of benzyl alcohol used for local anesthetic purposes and even by much larger doses than these.

kittens about two weeks old showed 0.25 cc. to be the lethal dose for each or inasmuch as each of the kittens weighed about 250 grams, about 1 cc. per kilo. Subcutaneous injections in cats of 1 cc. of pure benzyl alcohol per kilo were in some cases followed by recovery. In rabbits subcutaneous injections of 2 cc. of pure benzyl alcohol per kilo were sometimes fatal but more often the injections were followed by recovery. In dogs 2 cc. of pure benzyl alcohol per kilo weight of the animal injected intraperitoneally,

Fig. 1. Intravenous Injection of a Solution of Benzyl Alcohol 1 Per Cent. in Physiological NaCl.

Dog, weight 6.8 kilo. Paraldehyde anesthesia. Pressure low to start with. Note arrest of respiration before the heart; and drop in blood pressure, not excessive due to peripheral action on smooth muscle of the vessel walls.

TOXICOLOGY.

The effect of very large and toxic doses of benzyl alcohol was studied on mice, rats, guinea pigs, kittens, cats, rabbits and dogs.

It was found that the minimum lethal dose of pure benzyl alcohol for an ordinary white mouse weighing from 20 to 30 grams was 0.05 cc., which is equivalent to about 1 cc. per kilo weight. The minimum lethal dose for rats was found to be even larger than for mice, ranging from 1 to 3 cc. per kilo. The minimum lethal dose for guinea pigs was found to be from 1 to 2.5 cc. per kilo weight. Experiments on very young intramuscularly or subcutaneously, were never fatal.

Perhaps a clearer idea of the low toxicity of benzyl alcohol can be gained from the following protocols of experiments in which solutions of benzyl alcohol of from 1 to 4 per cent. in physiological saline were injected intravenously in rabbits and dogs without general anesthesia.

Experiment 10. Rabbit, 1,750 grams. Injected rapidly into ear vein 4 cc. of a 4 per cent. solution of benzyl alcohol in physiological saline. No effect on respiration. No convulsions. Complete recovery in fifteen minutes.

Experiment 12. Rabbit, 1,850 grams. Injected into ear vein rapidly 10 cc. of 4 per cent. solution of benzyl alcohol in physiological saline. Animal shows some general anesthesia. No effect on respiration. No convulsions. Complete recovery.

Experiment 14. Black and yellow dog, 8.7 kilo. Injected into leg vein with a syringe 40 cc. of 4 per cent. solution benzyl alcohol in physiological saline (equivalent to 160 cc. of a 1 per cent. solution). Respiration and pulse good. Animal lies quiet. Shows some general anesthesia; does not object to snipping its skin with scissors. Pupils dilated. Cornea slightly anesthetized. Half an hour later, complete recovery; animal runs around same as normal.

Experiment 16. Black and white dog, 7.3 kilo. Injected 40 cc. of a 4 per cent. solution benzyl alcohol in physiological saline. No toxic symptoms. Respirations and pulse regular. Complete recovery.

Even when an animal was in bad health and under the influence of a general anesthetic, it was found that comparatively large quantities of benzyl alcohol in aqueous solution could be administered to it without affecting the vital functions. This is well illustrated by the experiment shown in Figure 1, in which case a dog was completely narcotized with a somewhat excessive dose of paraldehyde and had a very low arterial pressure to start with and yet required about 20 cc. of 1 per cent. solution of benzyl alcohol intravenously to produce death.

FATE IN THE BODY.

WHILE EXPERIMENTS ON this subject are still in progress, it may be here stated that the data thus far obtained indicate that benzyl alcohol is in large measure excreted in the urine in the form of hippuric acid. From the author's experiments it would also seem that the rabbit may possibly produce this transformation more rapidly than the dog. The ability of the mammalian organism to take care of the poison undoubtedly is responsible in large measure for its low toxicity. It may be well to remark in this place, that this low toxicity of benzyl alcohol has incidentally been noted by Fraenkel[11] in a comparison of the toxicity of various phenols.

EFFECT ON TISSUES.

INASMUCH AS A local anesthetic in order to be of practical utility must not produce extensive destruction of tissue into which it is injected, observations were made on the action of benzyl alcohol in this respect. It was found that pure benzyl alcohol injected subcutaneously or intramuscularly was irritant and produced necrosis of tissue. In very case, however, in which this occurred there was never a pyogenic infection noted; the sloughing being of a sterile character. This is undoubtedly due to the marked antiseptic properties of pure benzyl alcohol. The destructive action of pure benzyl alcohol is not at all surprising as similar effects can be produced by antiseptics in general when injected into the tissues in the undiluted form.

Aqueous and saline solutions of benzyl alcohol, however, in the doses in which it has been used therapeutically by the author, namely, 1 to 4 per cent., were never found to produce any marked irritation or destruction of the tissues in which they were injected. Certainly no more irritation was produced by benzyl alcohol than by equivalent amounts of cocain and certainly also much more local irritation was produced by local injections of quinin-urea than by injections of benzly alcohol solutions. The most marked irritations following the use of benzyl alcohol in aqueous solution were noted in case of the conjunctiva in which case considerable congestion of the blood vessels was seen; but this vasodilatation could be easily antagonized by the addition of small quantities of epinephrin to the anesthetic.

DURATION OF THE ANESTHESIA.

IN ORDER TO BE AN efficient local anesthetic, a drug must exhibit its anesthetic properties for a period of time sufficient for the performance of an operation.

Laboratory experiments conducted by the author on the cornea, on nerve preparations, and on frog preparations such as described above showed that the anesthesia produced by benzyl alcohol lasted an appreciable period of time, even after the use of very dilute solutions of the anesthetic. Thus in the case of the frog's skin the immersion of a limb in a 1 per cent. solution of benzyl alcohol for one minute was sufficient to produce an anesthesia of the skin distinctly demonstrable a half hour and even longer after-

11. S. Fraenkel: Arzneimittelsynthese, Berlin, 1912, p. 261.

wards. Similar observations were made on sciatic preparations, and on the cornea.

The duration of the anesthetic effect of phenmethylol for practical purposes, however, could not be well determined by laboratory experiments but can be best learned from the study of clinical cases such as follow. It will be seen that the anesthesia produced by the weak solutions used was practically in all cases of sufficient duration for the completion of the operation and that is all that is to be desired of a local anesthetic. It may, however, be added, that the duration of the anesthesia produced by benzyl alcohol solutions is naturally dependent on the rapidity of absorption and that in very vascular areas as for instance in the case of inflammations and of spongy gums, the anesthesia did not last as long as in other cases, unless a tourniquet was applied wherever feasible. This, however, is true of all local anesthetics and is not peculiar to benzyl alcohol.

CLINICAL DATA.

IN VIEW OF THE marked local anesthetic properties of benzyl alcohol even in weak aqueous solutions found in the laboratory experiments and in view of the comparatively low toxicity of the drug as also determined by numerous experiments, and further more in view of the great difficulty and almost impossibility of obtaining the common well-known local anesthetics on the market on account of the existing war conditions, it was deemed justifiable to give benzyl alcohol very cautiously a trial in clinical cases. Accordingly with the kind cooperation of the surgeons in charge. the author had benzyl alcohol administered as a local anesthetic in a number of surgical cases in which it was necessary to perform operations under local anesthesia. Some of these cases were treated in the out-patient service of Prof. Wm. Halsted at the Surgical Clinic of the Johns Hopkins Hospital and others were performed outside. Up to the time of the writing of this paper the author has collected thirty-three surgical cases in which operations of lesser and greater extent were performed with local anesthesia produced by benzyl alcohol, and as will be seen from a résumé of the cases, the results obtained were highly successful. The following is a brief summary of the clinical data in hand.

Case 1. A. C. F 91189. Removal of a ganglion on the ventral aspect of a finger. Complete success.

Case 2. M. S. Complete destruction with an actual cautery of an epitheliomatous growth of the upper lip. Complete anesthesia.

Case 3. M. L. F 91187. Incision of an abscess on the back of the neck. Successful anesthesia.

Case 4. E. C. F 91342. Incision and evacuation of an abscess of the jaw. Successful anesthesia.

Case 5. L. M. F 91331. Incision of alveolar abscess. Efficient anesthesia.

Case 6. C. L. Opening of an abscess of the jaw. Effective anesthesia.

Case 7. Operation for the excision of an ingrowing toenail in a female patient, performed by Dr. O. Pancoast. Efficient anesthesia. Patient said that "if she had to do it over again, she would rather have the local anesthetic than ether."

Case 8. Infection of the hand. Very thick skin. Efficient anesthesia but slight pain complained of toward the end of the operation.

Case 9. E. F. F 91632. Excision of infected cervical glands in a patient with fever; complete and successful anesthesia. (Dr. R. H. Follis.)

Case 10. Opening of breast abscess. Complete anesthesia.

Case 11. W. M. F 19435. Abscess of the back. Exploratory incision. Efficient anesthesia.

Case 12. S. G. Complete excision of a rectal fissure by Dr. A. Hebb. Efficient anesthesia.

Case 13. R. W. B. F 92042. Extraction of a bullet from the hand. Complete anesthesia. Very successful case.

Case 14. W. W. F 51272. Dupuytren's contracture. Plastic operation performed by Dr. J. S. Davis with complete success. One per cent. solution used.

Case 15. C. S. F 67828. Infected finger; removal of the nail. Efficient anesthesia but some pain complained of toward the end of the operation. (Probably due to inefficient administration of the anesthetic by a student.)

Case 16. I. L. F 76292. Complete excision of external and internal hemorrhoids by Dr. A. Hebb, in a patient forty-two years old and suffering from chronic pulmonary tuberculosis. The patient's condition to start with was not very good and the author took repeated observations of his blood pressure and pulse. The hemorrhoids were removed with complete success under efficient anesthesia. Total amount of anesthetic injected was 9 cc. of a 1 per cent. solution in physiological saline. After the first injections the blood pressure which was 130 mm. at the beginning dropped to 120 and after later injections to 115, this being the lowest point reached. As the operation progressed the pressure rose to 120. The patient was able to go home immediately after the operation. Respiration was never affected throughout the operation.

Case 17. Dr. C. R. A. Removal of a mole on the face under benzyl alcohol anesthesia, 1 per cent. The doctor had another mole removed at another time under cocain anesthesia and stated that benzyl alcohol was equally efficient.

Case 18. Extensive plastic operation performed by Dr. J. S. Davis at the Union Protestant Infirmary; about 20 cc. of a 1 per cent. solution having been used in all. Complete anesthesia and perfectly successful operation.

Case 19. Excision of a pedicle of a pedunculated flap by Dr. J. S. Davis at the Union Protestant Infirmary. Successfully performed under completely efficient anesthesia produced by 1 per cent. solution of benzyl alcohol in physiological saline. In this case the total quantity of anesthetic used was one ounce or 30 cc. of a 1 per cent. solution.

Case 20. Thiersch skin graft performed by Dr. Davis at the Union Protestant Infirmary. Successful anesthesia.

Case 21. Removal of a wart from the hand by Dr. R. H. Follis with 3 per cent. benzyl alcohol; complete anesthesia.

Case 22-24. Extractions of teeth performed by Dr. I. L. Mansbach. In one of these cases a tooth was extracted painlessly by applying pure benzyl alcohol to the gums. In the two other cases teeth were extracted after injection of a 1 per cent. solution.

Case 25-30. Extractions of teeth performed successfully under phenmethylol anesthesia under the supervision of Dr. B. Holly Smith, Jr.

Case 31. R. S. F 91416. Operation for ingrown toenail in a female patient with 3 per cent. phenmethylol. Complete and perfect anesthesia. Tissues were cut out and scraped without any pain.

Case 32. F. C. F 39426. Case of Housemaid's Knee. Excision of bursa under 3 per cent. benzyl alcohol. Complete anesthesia.

Case 33. G. B. F 91837. Dermoid cyst of right upper eyelid extending deep into orbit. One and a half cubic centimeters of 3 per cent. benzyl alcohol were injected. There was considerable bleeding and the operation lasted about one hour, yet there was no pain felt by the patient throughout the operation.

In all of the above cases, unless otherwise stated, a 1 per cent. solution was used. In all the cases the healing of the wounds was not retarded or interfered with by the anesthetic. At the time of proofreading of this paper the total number of operations with phenmethylol anesthesia collected by the author was fifty.

DISCUSSION.

FROM THE DESCRIBED experimental data and clinical cases, it will be seen that benzyl alcohol is an efficient local anesthetic when administered in aqueous solution. It is a fortunate provision of nature that this alcohol is soluble up to 4 per cent. in water in physiological saline for these concentrations appear to be entirely efficient for practical purposes. The interesting features in connection with this drug which should be especially emphasized are in the first place its low toxicity as compared with that of the commonly employed local anesthetics. While the toxic dose of cocain is notoriously variable in different individuals, numerous cases can be found in the literature in which serious poisoning in the human being occurred after even small doses of that alkaloid which is our standard local anesthetic. Thus Mattison[12] reports a case in which eight drops of a 4 per cent. solution of cocain injected into the arm of a patient produced death. Abadie[13] reports death after some conjunctival injection of 40 mgm. of cocain in a woman seventy-one years old. The dentist Liller[14] reported a case of death after subgingival injection of 60 mgm. of cocain in a woman twenty-nine years old, and many other cases of cocain poisoning are described by Falk[15], Weigand[16] and others. In the laboratory experimentally the toxic and lethal doses given by various authors to various animals are as follows: For the guinea pig, Grode gives 20 mgm. of cocain per kilo as the minimal lethal dose. In rabbits the lethal dose of subcutaneous injection varies from 87 to 160 mgm. per kilo but on intravenous injection as little as 7.4 mgm. have produced death. In cats Anreps[17] gives 20 mgm. as the minimal lethal dose while Fisher[18] and Grode[19] give the lethal dose as 30 mgm. per kilo. For dogs Mosso[20] gives 30 mgm. as the average lethal dose. This is about the lethal dose for dogs found also by the present author. A glance at the above figures at once reveals the much lower toxicity of benzyl alcohol as compared with the local anesthetic alkaloids of which cocain is the standard representative. The next interesting and important feature in connection with benzyl alcohol as an anesthetic is the ability of the organism to metabolize it and excrete it in an innocuous form. Thirdly, an important feature of this local anesthetic must be certainly regarded as its high boiling point and the consequent ease of sterilization. Lastly, of great practical import-

12. MATTISON: Quoted by Grode.
13. ABADIE: Quoted by Grode.
14. LILLER: Quoted by Grode.
15. FALK: Therapeutische Monatschefte, 1890, p. 511.
16. WEIGAND: Dissertation, Berlin, 1897.
17. VON ANREPS: Pflüger's Archiv., Vol. xxi, p. 38.
18. FISHER: Dissertation, Bern, 1903.
19. GRODE: Arch. f. Exp. Path. Pharm., 1912, Vol. lxvii, 172.
20. MOSSO: Arch. f. Exp. Path. Pharm., 1912, Vol. xxiii, 153.

ance may be mentioned the comparatively low price of the drug and its ease of production.

In connection with the local anesthetic properties of benzyl alcohol and more particularly on the cornea, it is interesting to note that a few years ago a morphin derivative called Peronin or Benzyl-Morphin was shown to act as a local anesthetic for the eye. The local anesthetic properties of peronin have been described by Buffalini[21], Guaita[22] and Pierard[23]. In view of the pharmacological properties of benzyl alcohol described in this paper, it is evident that the local anesthetic properties of peronin are undoubtedly, in a large measure, due to the benzyl radicle in its molecule.

SUMMARY.

1. Laboratory experiments with benzyl alcohol or phenmethylol show that it possesses powerful local anesthetic properties, on the one hand, and a very low toxicity as compared with other well-known local anesthetics on the other.

2. A series of clinical cases in which weak solutions of phenmethylol were administered as local anesthetics for the performance of surgical operations proved that the drug is an efficient local anesthetic also in practical surgery.

3. It is considered that the anesthetic efficiency, the low toxicity, the simple excretion of the drug by the organism and the ease with which benzyl alcohol solutions can be sterilized, will render it a useful therapeutic agent in medicine and surgery.

The author takes great pleasure in expressing in this place his gratitude to the surgeons Drs. R. H. Follis, O. Pancoast, J. Staige Davis, Arthur Hebb, and H. L. Homer, and to the dentists Drs. B. Holly Smith, Jr., and I. L. Mansbach for their kind cooperation in testing out the efficiency of the drug in clinical cases.

21. Buffalini: Quoted by Gwathmey in his Textbook on Anesthetics. N. Y., 1914.

22. Guaita: Quoted by Gwathmey in his Textbook on Anesthetics. N. Y., 1914.

23. Pierard: Quoted by Gwathmey in his Textbook on Anesthetics. N. Y., 1914.

GREATNESS IS NOT IN ELEVATION, BUT IN PERCEPTION. THE TOP OF THE MOUNTAIN AND THE HIGHEST RUNG OF THE LADDER ARE VERY GOOD FIGURES OF SPEECH; BUT GREAT MEN—SUCCESSFUL MEN OF EVERY SORT—DO NOT LIVE UP THERE. THEY STAY ON A COMMON FOOTING WITH THE GREAT MASS OF MANKIND. THEY HAVE A COMMON BOND WITH THEM, ONLY THEY SEE AND FEEL MORE. THEY FEEL AND UNDERSTAND AS OTHER MEN DO, BUT MORE PENETRATINGLY, MORE CLEARLY. THEY KNOW THE VALUE OF ORDINARY THINGS IN A WAY ORDINARY MEN DO NOT.

—*William H. Hamby.*

THE COMPARATIVE EFFICIENCY OF LOCAL ANESTHETICS . THE INVESTIGATION OF THE CLINICAL EFFICIENCY OF LOCAL ANESTHETICS BY EXPERIMENTAL METHODS . CRITERIA OF USEFULNESS . METHODS OF ESTIMATING ANESTHETIC EFFICIENCY . SCOPE OF THE VARIOUS EXPERIMENTAL METHODS . SYNOPSIS OF THE RESULTS OF THE INVESTIGATIONS . EFFICIENCY RATIO OF THE ANESTHETICS . RAPIDITY OF THE ONSET AND DURATION OF ACTION . THE EFFECT OF ALKALIZATION . EPINEPHRIN . COMBINATIONS OF ANESTHETICS . SUMMARY . THE COMPARATIVE VALUES OF SOME LOCAL ANESTHETICS . COCAIN, NOVOCAIN, APOTHESIN AND KCL . MOTOR NERVE ANESTHESIA . SURFACE ANESTHESIA . INTRACUTANEOUS METHOD . SUMMARY OF RESULTS IN ANIMAL AND HUMAN EXPERIMENTS .

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SO MUCH INTEREST has recently been shown in the more extended use of local anesthetics that Torald Sollmann of Cleveland, O., partly supported by a grant from the Committee on Therapeutic Research of the Council of Pharmacy and Chemistry of the A. M. A., has reviewed the whole subject of the comparative efficiency of local anesthetics in the Pharmacological Laboratory of the Western Reserve University School of Medicine. Space does not permit the republication of Sollmann's full papers, originally contributed to the Journal of Pharmacology and Experimental Theraputics, so his detailed report on his observations and conclusions, as presented in the Journal A. M. A., January, 1918, is used instead. Sollmann's researches were divided into two parts, both of which are herewith reprinted in their condensed form:

PART I. THE INVESTIGATION OF THE CLINICAL EFFICIENCY OF LOCAL ANESTHETICS BY EXPERIMENTAL METHODS.

CRITERIA OF USEFULNESS.—The substances that have been introduced as local anesthetics are so numerous that it is difficult properly to compare their value. This has been attempted in a considerable number of experimental investigations; but the results have rather confused than cleared the subject. The confusion is due largely to faulty interpretation and unwarranted extension of the results into fields to which they do not apply, or to the failure properly to analyze and reproduce the essential factors of the clinical use of these agents.

The clinical desirability of a local anesthetic is determined on the one hand by its anesthetic efficiency, and on the other hand by the degree of local irritation and by the systemic toxicity.

Systemic toxicity has usually been estimated by hypodermic injection into guinea pigs. The value of this method is extremely doubtful. The choice both of the animal and of the channel of administration is unfortunate from a clinical standpoint. Rodents depart much more widely than do dogs or cats from human subjects in their response to various poisons. They are, therefore, of questionable value even for the determination of *absolute* toxicity. *Actual* toxicity further involves the rate of absorption. Rapid destruction renders this especially important for the local anesthetics. Most cases of human poisoning arise from application to mucous membranes. The absorption from these, of course, has no relation to the absorption from hypodermic injections in guinea pigs.

Local irritation is best estimated by clinical application. In fact, clinical experience soon limited the use of the more irritant of the anesthetics, such as stovain, acoin, and the higher concentrations of quinin-urea hydrochlorid.

It seemed advisable to divide the problem, so that the present investigation does not touch further on the questions of irritation and toxicity, but is confined to the subject of anesthetic efficiency.

The methods most widely used for the estimation of anesthetic efficiency consist in observing: (1) the abolition of motor irritability of the frog's sciatic nerve, immersed in the solutions; (2) the failure of the frog, intact or, better, decapitated, to retract the irritated foot after its immersion in the solution; (3) abolition of the winking reflex after application to the cornea, and (4) abolition of sensation after intracutaneous injection in the human subject.

Many series of determinations have been made with one or several of these methods, the efficiency being judged sometimes by the minimal efficient concentration, and sometimes by the duration of the effect, but often without a clear understanding of the relation of these various experimental methods to the various clinical methods.

METHODS OF ESTIMATING ANESTHETIC EFFICIENCY.

LOCAL ANESTHETICS ARE USED clinically in several very distinct ways, especially on mucous surfaces (surface anesthesia); by infiltration and hypodermic injection (injection anesthesia); by intraneural injection, and by subdural (spinal) injection.

Each of these clinical methods involves not only the factor of the *absolute* efficiency but also the balance between the penetration to the nerve fibers, and of absorptive removal from the anesthetic region.

With these considerations in mind, I have employed and compared all these experimental methods, and a further method of direct application to the sensory fibers of the sciatic trunk (testing their excitability by the persistence of the reflexes). The results appear to justify definite conclusions as to the scope of these methods, and as to the availability of the tested anesthetics for clinical purposes.

1. The application of the anesthetics to the motor fibers gives concordant results that are of scientific interest; but these results cannot be transferred to sensory fibers and therefore have little practical value.

2. The sensory methods fall into two classes: (*a*) the application to mucous surfaces, illustrated by the cornea or frog-skin and corresponding to the clinical use in the eye, nose, throat, urethra and bladder, and (*b*) the direct application of the anesthetic to the nerves, either by injection, or by immersion of the exposed nerves. The methods of the second class (*b*) are illustrated, respectively, by the intracutaneous (wheal) method, and by the application to the sensory nerve of the frog.

SCOPE OF THE VARIOUS EXPERIMENTAL METHODS.

Experimental Method	Adaptation to Clinical Problems
Intracutaneous ..	Absolute anesthetic efficiency. Infiltration and injection anesthesia. Intraneural injection.
Intracutaneous and sensory nerve trunk ...	Suggestive for subdural injection.
Cornea and frog-skin	Anesthesia of mucous membranes (the frog-skin test being less satisfactory because of the absence of circulation, and the different structure of the mammalian mucosae).

THE INTRACUTANEOUS METHOD gives the closest approximation to the absolute anesthetic efficiency: it does away entirely with the factor of pentration, since the solution comes into direct contact with the fine nerve fibers. Absorptive removal of the drugs can be practically obviated, either by making the observations very shortly after injection, or by the addition of epinephrin.

In addition to this scientific value, the wheal method is important because its results can be transferred directly and quantitatively to the clinical method of infiltration and intraneural anesthesia.

Immersion of the nerve trunk into the anesthetic solution, and testing the response of the sensory fibers, seem to approach closely the clinical methods of subdural injection. However, the clinical conditions are complicated by the undetermined factor of the rate of penetration in human spinal nerves; by the absorptive removal, and by the reaction of the cerebrospinal fluid. It is conceivable, therefore, that the order of clinical efficiency for intraneural injection may differ more or less from the experimental efficiency, by either the intracutaneous or the nerve-trunk method. These, therefore, can be considered only as suggestive.

In the light of the foregoing, the scope of the various experimental methods may be defined as in the accompanying tabulation.

PART II. SYNOPSIS OF THE RESULTS OF THE INVESTIGATIONS.

THE METHODS OF experimentation and analysis, as sketched in Part I, have been applied to those local anesthetics that appear to have maintained themselves in clinical practice, and also to a few other substances which have not been used extensively in the clinic, but which appear worth investigating from the same standpoint.

I shall present the results mainly in the form of diagrams, dispensing with the details. These can be found in the full papers published in the Journal of Pharmacology and Experimental Therapeutics.

EFFICIENCY RATIO OF THE ANESTHETICS.

THIS IS SHOWN in Figures 1 and 2. Figure 1 represents the methods that reproduce injection anesthesias.

Figure 1*A* shows the results of the intracutaneous method, indicating the absolute efficiency; it corresponds also to the practical efficiency for infiltration, injection and intraneural anesthesia.

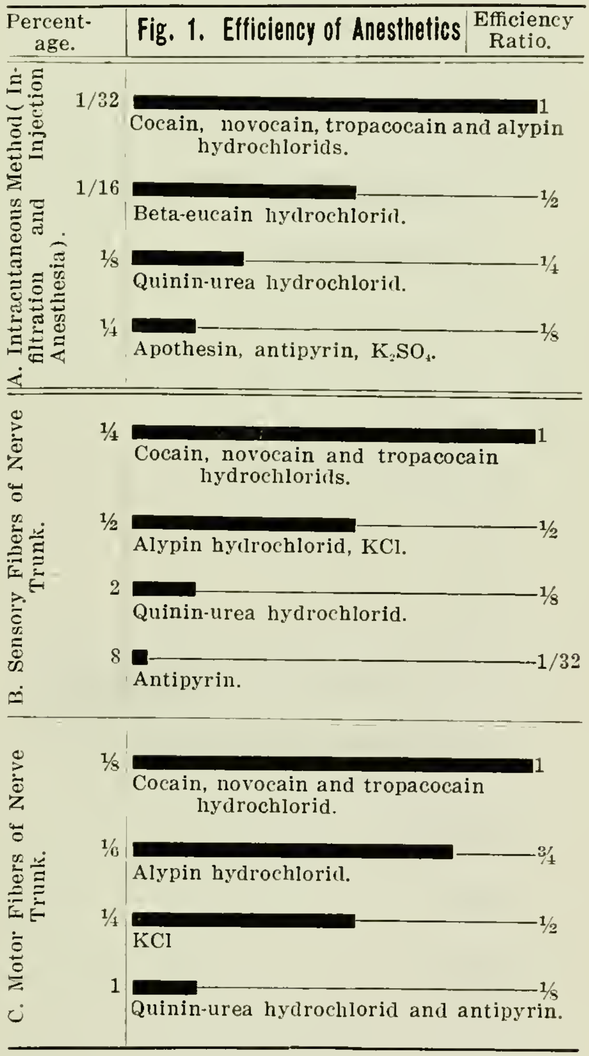

Fig. 1.—Efficiency of anesthetics in injection anesthesias.

Figure 1*B* shows the results of the direct immersion of the nerve trunk, for the sensory fibers. It probably approaches the conditions of subdural injections (potassium chlorid may behave differently on subdural injection).

Figure 1*C* gives the corresponding results for the motor fibers. They agree fairly well with the sensory fibers.

Figure 2 represents the methods of surface anesthesia.

Figure *2A* shows the results for the cornea, which is probably fairly representative of mucous membranes.

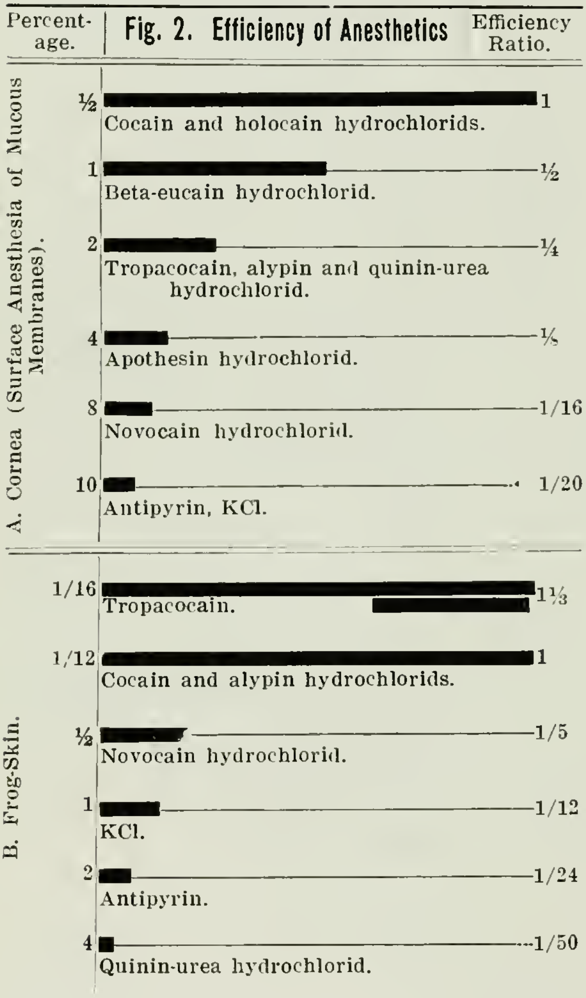

Fig. 2—Efficiency of anesthetics in surface anesthesia.

Figure *2B* gives the results with the frog-skin, which are in the same class, but are less related to the clinical conditions.

Rapidity of the Onset of Action.—This has no practical importance for infiltration anesthesia, since the action is almost instantaneous with this method. The rapidity is somewhat more significant for surface anesthesia, but even here the differences do not appear to have much practical importance. For the cornea, with the minimal effective concentrations, the anesthetics (hydrochlorids) could be arranged in three groups:

Most rapid: Tropacocain, alypin, quinin-urea.

Intermediate: Beta-eucain.

Slower: Cocain, novocain, holocain.

Duration of Action.—This varies, mainly according to the rate of absorptive removal. It is of some practical importance for surface and subdural anesthesia, but it matters very little for infiltration anesthesia, for in this, the duration can be prolonged at will by the addition of epinephrin (except with tropacocain).

There are no experimental data on the duration of action after subdural injection. The corneal method, however, furnishes direct information for surface anesthesia. The time (in minutes) required for complete recovery after the application of the minimal concentrations producing complete anesthesia was (for hydrochlorids):

From ten to fifteen minutes: cocain, tropacocain.
From twenty to thirty minutes: alypin, beta-eucain, holocain.
Fifty minutes: novocain.
Sixty-five minutes: quinin-urea.

THE EFFECT OF ALKALIZATION.

O. GROS FOUND that the addition of alkali increases very noticeably the efficiency of cocain and of the synthetic anesthetics, doubtless because the free anesthetic bases penetrate more readily than the salts. His results were based mainly on the motor fibers of nerve trunks.

My results confirm this potentiation for the motor-nerve trunk, and extend it to the sensory fibers of nerve trunks, to the frog-skin and to the cornea. On the other hand, no potentiation occurred on intracutaneous injection, evidently because this does not require pentration.

Accordingly, the addition of sodium bicarbonate, as suggested by Gros, serves no useful purpose for infiltration anesthesia. It may be of some use for intraneural and possibly for subdural injections, and it would be definitely useful for surface anesthesia. For these uses, the anesthetic should be made up in double concentration, and diluted, just before use, with an equal volume of 0.5 per cent. sodium bicarbonate. This increases the efficiency (for the cornea) as follows: Cocain, from one to two times; beta-eucain, two times; novocain, from two to four times; tropacocain or alypin, four times. For instance, a 0.5 per cent. solution of alypin in 0.25 per cent. sodium bicarbonate is just as effective as a 2 per cent. solution of alypin (the hydrochlorid) in plain saline.

This effects a considerable saving in anesthetic. It is not certain whether or not it modifies the toxicity.

Alkali should not be added to holocain or to quinin-urea.

EPINEPHRIN.

THIS WAS INTRODUCED mainly by H. Braun, to prolong the local anesthetic action for infiltration and injection anesthesia. It is notably effective for this purpose. With intracutaneous injection, the anesthesia is prolonged for hours (tropacocain is an exception, since this destroys the vasoconstrictor action of epinephrin). The actual efficiency is not increased, so that there is no true synergism. The epinephrin acts solely by preventing the absorptive removal of the drugs. In practice, this means that the anesthesia can be maintained for the duration of an operation with much less drug, thus diminishing the chances of systemic toxicity, and obviating waste of anesthetic. The addition of epinephrin (about 1:50,000) is therefore advised for all injection anesthesias (except tropacocain).

On the other hand, epinephrin is quite useless for surface anesthesia; indeed, it rather diminishes the penetration and therefore the efficiency of the anesthetics on mucous membranes (cornea). I also doubt whether it would be of service in intraneural or subdural injections.

COMBINATIONS OF ANESTHETICS.

THE EFFICIENCY OF mixtures of the local anesthetics corresponds to more or less complete summation, without any potentiation. In other words, if two solutions of different anesthetics are diluted until they are "just effective," then a mixture of the two solutions will also be "just effective"—no more and no less.

A single exception to this rule exists, namely, the potentiation of potassium with certain of the other anesthetics, discovered by Hoffmann and Kochmann. I have confirmed this for motor paralysis; but I cannot confirm it for sensory anesthesia. It has, therefore, no practical importance.

There would be little or no advantage in mixing the synthetic anesthetics with each other, except, perhaps, in mixing any of the synthetic anesthetics with quinin-urea, or with potassium chlorid. These are rather too feeble by themselves; but when they are used in nonirritant concentrations, being employed to take the place of a part of the synthetic anesthetics, the toxicity of the latter is correspondingly reduced.

SUMMARY.

THESE INVESTIGATIONS of the local anesthetics justify the following conclusions, as to their suitability for clinical uses, mainly from the standpoint of efficiency:

1. For the anesthesia of mucous membranes, the relative efficiency is shown in Figure *2A*. The numbers at the left show the percentages needed to equal 0.5 per cent. cocain hydrochlorid. Cocain, beta-eucain, alphin and tropacocain are the most useful; quinin-urea hydrochlorid is fairly active. Apothesin, novocain and potassium chlorid are relatively inefficient. Alkalization increases the efficiency from two to four times. The solutions of the anesthetic salts may therefore be mixed with an equal volume of 0.5 per cent. sodium bicarbonate, without loss of efficiency, and with a saving of one half of the anesthetic. The mixtures, however, do not keep well, and should be recently made.

The addition of epinephrin does not increase the efficiency, and is probably useless.

2. For infiltration and injection anesthesia, the relative efficiency is shown in Figure *1A*. Cocain, novocain, tropacocain and alypin are about equally efficient. Beta-eucain and quinin-

urea hydrochlorids are intermediate; apothesin and potassium sulphate (or chlorid) are relatively inefficient.

The efficiency is not increased by alkalization. Epinephrin greatly prolongs the action, and should always be added (except to tropacocain).

The anesthetic action of potassium sulphate or chlorid is not great enough to be of real value. A 1 per cent. (that is, isotonic solution) would be equivalent to about 0.125 per cent. of cocain or novocain. However, it may well be used in place of sodium chlorid for making anesthetic solutions, as suggested by Braun.

Several of the synthetic anesthetics can completely take the place of cocain. In view of this fact, it would be feasible to prohibit entirely the importation, manufacture, sale and use of the habit-forming cocain, except for scientific purposes.

SUPPLEMENTING THE RESEARCHES of Sollmann, herewith presented in the Year-Book, Herbert C. Hamilton, working in the Research Laboratory of Parke Davis & Co., has devoted especial attention to determining the analgesic efficiency of apothesin, a recent addition to the list of local anesthetics, which has proved to be not merely a substitute for cocain and novocain, but a product worthy of the closest investigation. Publishing his experimental data in the Journal of Laboratory and Clinical Medicine, November, 1918, Hamilton maintains that:

The reason advanced by Sollmann[1] for reopening an investigation of local anesthetics namely "the wish to select 'the best'" is sufficient reason for this publication, with the added incentive that while his work is apparently comprehensive, covering as it does the efficiencies of a number of substances by five different methods of evaluation, the whole field is not fully covered, since apothesin is included in the tests of only two of the five series.

The first series of his experiments, and the first one appearing in complete detail,[2] is that describing the comparison of a number of local anesthetics on the sciatic nerve of the frog. One would assume from reading the first article that apothesin had not then come to the author's attention.

In two subsequent test-methods, however, it is included—in the cornea test and in the intracutaneous test. Based on the results obtained by the first of these two methods he concluded that novocain and apothesin are inefficient relatively to cocain, although apothesin is 100 per cent. more active than novocain. In the intracutaneous test his results would indicate that novocain is fully equal to cocain while apothesin is only one-eight as efficient.

Since Sollmann's experiments led him to conclusions radically different from those which we have observed the subject is reopened to include the comparison of apothesin with other anesthetics by three of the methods he applied and to point out what are evidently errors in his work.

As in Sollmann's paper this publication does not touch on the toxicity since there are different interpretations to be placed on results obtainable by almost any method. The important feature in this respect is that apothesin is only one-fifth as toxic as cocain by subcutaneous injection into guinea pigs and that in relatively large doses no systemic effects have been in evidence. Local irritation, too, is a clinical problem and may logically be omitted from this discussion.

As to the relative merits of the different methods of examination of local anesthetics this too must be left to the ultimate judgment of the clinician. The use of a new anesthetic is necessarily governed by its relative efficiency, first of all as shown by laboratory tests but finally by observation of its action in practical use.

1. Sollmann: Jour. Am. Med. Assn., 1918, Vol. vii, 216.

2. Sollmann: Jour. Pharm. and Exp. Therap., 1917, Vol. x, 379.

Among the laboratory tests that have been devised for investigation of local anesthetics there are three, each of which appears to have a very direct bearing on the clinical application of these substances, namely—the intracutaneous, comparable to infiltration anesthesia; the nerve trunk anesthesia, comparable to nerve blocking or conduction anesthesia; and surface anesthesia—the mucous membrane of the eye, nose and throat—reproduced by application to the frog's foot or to the cornea.

If the results of testing the different local anesthetics by the different methods agreed relatively, this would show that comparison by any one of the methods would give the relative efficiencies. That this is not true, however, is apparently shown by observing the varying ratios obtained by both Sollmann and ourselves. The laboratory results are therefore only suggestive, and do not absolutely demonstrate the clinical value of a local anesthetic.

In the following experiments the hydrochlorids of each of the local anesthetics tested were used in every case, no experiments having been conducted after neutralization. Experiments with mixed anesthetics were also omitted as having no direct bearing on the object of the paper.

MOTOR NERVE ANESTHESIA.

THE METHOD MOST COMMONLY used for testing the value of a local anesthetic where exact data is desirable, is to apply the anesthetic to the sciatic nerve of the frog, the nerve being separated at its point of branching from the spinal column. The objection has been made that this is a determination of motor nerve anesthesia only and no evidence of efficiency on the sensory nerves. It has been demonstrated, however, that the sensory nerves are the first to be anesthetized[3] and therefore a measure of motor nerve anesthesia is a fair indication that the sensory nerves are at least equally anesthetized. Objection has also been made that this method is very different from the practical use of anesthetics, but on this point, too, there are counterbalancing reasons which give the method practical value for measuring anesthetics. This test shows at once the nerve blocking value such as results from subcutaneous and subdural injections and as this is one of the uses of local anesthesia, its measurement is of primary importance. This method also meets one of the requirements of physiological testing in its accuracy of measurement, the exposed nerve can so easily be irritated to determine the degree of anesthesia when either the strength of solution or the length of time is the measuring factor. The accuracy of measurement is not affected by the factors which may affect the intracutaneous method, one of which is the pressure of the solution and another its character, such as tonicity, concentration, irritation, diffusibility.

As a sole method of valuing local anesthetics it would fail to give a true picture, but taken as one of several methods, especially along with that of subcutaneous administration the nerve blocking action is undoubtedly of primary importance and deserves especial consideration.

This phase of the subject has been so thoroughly covered by other investigators that no further description is necessary and only additional data or materially different results furnish an adequate reason for further publications.

While working with the intent to verify or disprove Sollmann's results the method followed was varied to the extent that no work was carried out with the high dilutions he employed, these having no practical bearing on the subject. It was planned to use such dilutions only as would bring about complete anesthesia in five to ten minutes but the lower time limit was in no case sufficient with the dilutions used.

The irritation was produced from a three cell battery through a secondary with 5,000 windings adjusted to a point where the current is just perceptible on the tongue.

The sciatic nerve of the frog is dissected, leaving a small piece of the bone attached, for convenience in handling, and having the whole muscle below the knee skinned but otherwise intact.

After determining that its response to stimulation is good, the whole nerve-muscle preparation

3. Braun: Local Anesthesia, Translated by Shields, ed. 3, 80.

is immersed in the solution, testing frequently after five minutes to determine when anesthesia begins and its progress. It will be observed that no account is taken of certain features which have formed an important part of the reports of other investigators, namely, the response to varied degree of current, the response from application of stimulus to different portions of the nerve, the exact beginning of paralysis, its duration or the recovery. While these factors are not unimportant this series of tests was made primarily to compare the efficiency of several local anesthetics, and for this purpose, one end point may be considered as good as another, other things being equal. The end point chosen was therefore that dilution which would paralyze the motor nerve all the way to its disappearance into the tissue below the knee, in a period of approximately ten minutes. However, for comparison and as evidence of different degrees of anesthesia records of other times and of other dilutions are included.

In the table, — means practically no degree of anesthesia, ± means partial anesthesia in the sense of progress along the nerve, + means complete anesthesia except the nerve just at its disappearance into the tissue of the leg.

From Table I the efficiencies of the four anesthetics are apparently so nearly equal that for all practical purposes their values by this method may be taken as equal, as shown by Table II which summarizes the results.

Comparison of these results with those of Sollmann shows that there is absolute agreement in ratio so far as each of us carried our experiments but that the efficient concentrations used are somewhat different. This is probably due to the selection of different constants and not to errors on either side.

The added data on apothesin is valuable, since the virtual agreement on the others points to a probable agreement on this substance.

SURFACE ANESTHESIA.

THE METHOD IS THAT of Gradenwitz[4] who first applied it as a means of determining the relative values of local anesthetics. The brain, medulla and heart of the frog are removed and the blood washed out to prevent general absorption of the substance which is being tested. In applying this method, one leg, after removing excess moisture, is dipped into the diluted anesthetic for 1 minute, after which it is laid in a vessel containing cold water but with the legs not immersed and separted so that none of the anesthetic touches the control leg. At five minute intervals both feet are dipped into a weak solution of hydrochloric acid (about ⅕ per cent.) and the behavior closely observed. When no anesthesia has taken place both legs are withdrawn with equal promptness while as anesthesia progresses the treated leg is more slowly withdrawn until on complete anesthesia it is not withdrawn at all while the control leg reacts as promptly as at first. After each stimulation both

TABLE I.

ANESTHESIA AS SHOWN BY RESPONSE TO CURRENT AFTER MINUTES.

Substance	*Dilution Per Cent.*	0	5	8	10	12	15	20	25
Cocain	0.5	—	—	±	±	+			
		—	—	±	±	±	±	±	+
		—	—	±	±	±	±	+	
Cocain	1.0	—	—	±	+				
		—	—	±	±	+			
		—	—	±	±	+			
Novocain	0.5	—	—	±	±	±	±	+	
		—	—	—	±	±	±	±	+
		—	—	±	±	±	±	+	
Novocain	1.0	—	—	±	±	+			
		—	—	±	+				
		—	—	±	±	+			
		—	—	±	±	+			
		—	—	±	±	+			
Apothesin	0.5	—	—	±	±	±	+		
		—	±	±	±	+			
		—	—	±	±	±	±	+	
		—	—	±	±	+			
		—	—	—	±	±	±	±	+
Apothesin	1.0	—	—	±	+				
		—	—	±	+				
		—	±	+					
		—	—	±	+				
		—	—	±	±	+			
KCl	0.5	—	—	—	—	±	±	±	+
	1.0	—	±	±	±	+			

4. GRADENWITZ: Ber. klin. Wchnschr., 1899, Vol. xxxvi, 76.

legs are dipped in water to remove any adhering acid.

The objection has been raised that there is no direct relationship between this method and clinical practice; on the other hand the frog's skin being always moist is in a sense comparable to the mucous membrane and, in this respect, is an experimental method for obtaining relative values for mucous membrane anesthesia. Besides, it is a method with a reaction susceptible of

TABLE II.

TIME IN MINUTES REQUIRED FOR COMPLETE ANESTHESIA OF THE WHOLE LENGTH OF THE SCIATIC NERVE.

	.05 Per Cent. Solution	*1 Per Cent. Solution*
Cocain	12-25	10-12
Novocain	20-25	10-12
Apothesin	15-25	10-12
Potassium Chlorid	25	12

quite exact measurement and as such takes its place as a valuable pharmacologic assay method for establishing relative values. The values so obtained may not be capable of direct application as has been stated about other methods but without question, they are not to be ignored in assigning the real position of a local anesthetic.

Table III shows the detailed results in which equally prompt withdrawal of the legs is represented by —, progressive anesthesia by ±, while complete anesthesia of the treated member only is represented by +. When neither leg will respond to stimulation this condition is represented by 0.

Comparing these relative efficiencies with those obtained by Sollmann it is seen that he found it necessary to use a solution of novocain six times as strong as that of cocain as against one three times as strong in Table III. Also that of KCl,

TABLE III.

Substance	*Dilution Per Cent.*	*Time and Result of Observation* 5	10	15	20	25	30	35	40	45
Cocain	2	+	+	+	+					
	2	+	+	+	+			0		
	1	+	+	±±			0			
	1	+	±±	±±	±	±	±	±	0	
	½	±	±	±	±	±±±	0			
	½	±	±±±	±±±	±±	±±±	±±±	0		
	⅔	—	±	±	±±	±±±	±±±	±±±	±±±	0
Novocain	2	—	±	±						
	2	—	±	±			0			
	2	—	±	±			0			
	3	—	±	+±	±±	+±	+±	+	0	
	3	—	—	—	±	±	±±	±±	+±	
	3	—	±	±±	+	0				
	3	—	±	±±	±±	+±+	0			
Apothesin	2%	0	±	±	±	+	0			
		—	±	±	—	0				
		±	±	±	±±	±±	±			
Apothesin	3	—	±	±±	±±	+±+	+	+	±±±	
	3	—	±	±±	±±	±±	+	0		
	3	±±	±	±±	±±	±±	+	+	0	
	3	—	±±±	±±±	±±±	0				
KCl	1	—	±	±	—	—	0			
	2	—	±	±	±	±	—	0		
	3	+	+	+	±±	±±	±±	±±	0	
	2½	±	±±	±	±±	±±	±±	0		

SUMMARY—TABLE IV.

Substance	*Effective Dilution*	*Ratio of Effectiveness*
Cocain Hydrochlorid	1 per cent.	1
Novocain	3 per cent.	⅓
Apothesin	3 per cent.	⅓
Potassium Chlorid	3 per cent.	⅓

the efficient strength was twelve times as great as for cocain against three times in Table II.

INTRACUTANEOUS METHOD.

THIS METHOD HAS THE distinct advantage of most nearly duplicating one of the important uses of a local anesthetic since it is carried out in a way almost identical with that in clinical practice. Particular care was taken in the tests tabulated below to prevent the unintentional prejudice which knowledge of what was injected might have.

The injections were made by a practicing physician into the forearms of the subjects, who were asked to respond only when pain was felt when a needle prick was made on the anesthetized area or the adjacent skin.

EXPERIMENTS ON FIRST SUBJECT (H. C. H.)
FIRST SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.25 cc.	1-500	Complete
Novocain	0.25 cc.	1-200	Complete
Apothesin	0.25 cc.	1-200	Complete
Phys. Salt Sol.	0.25 cc.		No anesthesia

Anesthesia was so complete that no distinction could be drawn between the different injections. The second series was therefore made with the same ratio of strengths but each reduced to half that in the preceding series.

SECOND SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.2 cc.	1-1000	Complete
Novocain	0.2 cc.	1-400	Complete
Apothesin	0.2 cc.	1-400	Complete

In this test while anesthesia was complete in every case it seemed more persistent in the area injected with apothesin and in the next series the strength of the latter only was changed.

THIRD SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.2 cc.	1-1000	Complete
Novocain	0.2 cc.	1-400	Complete
Apothesin	0.2 cc.	1-800	Complete

In this series the anesthesia was as nearly identical as impartial observation could recognize.

The experiments were continued the next day on the same subject.

In the data below an attempt is made to indicate the degree of anesthesia and its duration by the number of plus signs.

FIRST SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.2 cc.	1-1000	++++
Novocain	0.2 cc.	1-500	+++
Apothesin	0.2 cc.	1-1000	++++

SECOND SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.2 cc.	1-2000	++
Apothesin	0.2 cc.	1-2000	+

THIRD SERIES.

	Amount	*Dilution*	*Result*
Cocain	0.2 cc.	1-2000	++
Apothesin	0.2 cc.	1-1500	++

The above injections were made with not to exceed a minute interval between those of a series.

The results of these tests are summarized in Table V.

TABLE V.

Substance	*Dilution*	*Ratio*
Cocain	1-2000	1
Novocain	1-1000	½
Apothesin	1-1500	¾

Experiments on a second subject (M. W.) were carried out, the degree of anesthesia being indicated roughly by the number of plus signs.

EXPERIMENTS ON SECOND SUBJECT.
FIRST SERIES.

	Dilution	Result
Cocain	1-2000	+++
Novocain	1-1000	++
Apothesin	1-2000	+++

SECOND SERIES.

	Dilution	Result
Cocain	1-3000	++
Novocain	1-2000	+
Apothesin	1-3000	++
Novocain	1-1000	++

These results may be summarized in Table VI.

TABLE VI (M. W.)

	Dilution	Ratio
Cocain	1-3000	1
Novocain	1-1000	⅓
Apothesin	1-3000	1

On a third subject (W. E. K.) the results were as follows:

EXPERIMENTS ON THIRD SUBJECT.
FIRST SERIES.

	Dilution	Result
Cocain	1-3000	+++
Novocain	1-1800	++
Apothesin	1-3000	+++

SECOND SERIES.

	Dilution	Result
Cocain	1-4000	++
Novocain	1-2000	+
Apothesin	1-4000	++

TABLE VII (W. E. K.)
SUMMARY ON THIRD SUBJECT.

Substance	Dilution	Ratio
Cocain	1-4000	1
Novocain	1-1800	less than ½
Apothesin	1-4000	1

EXPERIMENTS ON FOURTH SUBJECT (L. W. R.)
FIRST SERIES.

	Dilution	Result
Cocain	1-2000	+++
Novocain	1-1000	++
Apothesin	1-2000	+++

SECOND SERIES.

	Dilution	Result
Cocain	1-3000	++
Novocain	1-1800	++
Apothesin	1-3000	+

THIRD SERIES.

	Dilution	Result
Cocain	1-4000	+
Novocain	1-1500	++
Apothesin	1-4000	+

FOURTH SERIES.

	Dilution	Result
Cocain	1-3000	++
Apothesin	1-3000	++

Summarizing these results the ratios are shown in Table VIII and IX.

TABLE VIII.

Substance	Dilution	Ratio
Cocain	1-3000	1
Novocain	1-1500	½
Apothesin	1-3000	1

TABLE IX.
SUMMARY OF AVERAGE RESULTS BY INTRACUTANEOUS ADMINISTRATION.

Substance	Ratio
Cocain	1
Novocain	11/24
Apothesin	15/16

The results of the intracutaneous administration of the three local anesthetics summarized above, carried out as they were on four different persons prove conclusively two points, (1) novocain is about one-half as efficient as cocain, (2) apothesin is practically equal to cocain in anesthetic value. Sollmann's conclusions from his test by this method, namely, that novocain is equal to cocain, and apothesin one-eighth as efficient are evidently incorrect. It is impossible to explain this discrepancy. Novocain anesthesia is well known to be less permanent since most observers have noted quick recovery. This, however, was not the factor in these tests since the time of recovery was only incidental in importance as compared with the degree of anesthesia from the high dilutions.

In the introduction it was stated that since tests of local anesthetics by different methods do not show entire agreement, they can be taken as only suggesting and not demonstrating the clinical value. Viewed in another way, however, it may be said that these tests demonstrate comparative efficiencies in the particular method of applying the substance.

ments have, however, shown that by doubling the dose of novocain so as to make it as effective as cocain, and at the same time by adding certain substances (suprarenin) novocain has become an ideal anesthetic for injection of tissues and has made cocain unnecessary." It may be assumed therefore that this method correctly measures the efficiency of apothesin as well as those of cocain and novocain. Verification of the motor-nerve method can not be cited at this time.

TABLE IX.

Substance	*Method*	*Graphic Illustration of Efficiencies*	*Ratio*
	Motor Nerve		1
Cocain	Surface	- -	1
	Intracutaneous	++++++++++++++++++++++++++++++++++	1
	Motor Nerve		1
Novocain	Surface	- - - - - - - - - - - - - - - -	⅓
	Intracutaneous	++++++++++++++++++	½
	Motor Nerve		1
Apothesin	Surface	- - - - - - - - - - - - - - - -	⅓
	Intracutaneous	++++++++++++++++++++++++++++++++++	1

That both novocain and apothesin are inferior to cocain by surface application agrees with clinical evidence which has demonstrated cocain to be exceptionally rapid in its absorption from mucous surfaces, (Braun).[3] The comparative efficiencies of cocain and novocain by intracutaneous injection also duplicates the opinion generally held that the latter is less efficient. On this point, Braun[3] states: "Experience and experi-

Based on the foregoing results it is evident that from every point of view apothesin is equal to or exceeds novocain as a local anesthetic and in some respects is not less efficient than cocain.

The author's appreciation is extended to Dr. A. W. Lescohier, who carried out the intracutaneous tests and recorded his observations; also to three associates who by their courtesy made more data available.

LOCAL ANESTHESIA IN GENERAL SURGERY . THYROIDECTOMY UNDER LOCAL ANESTHESIA . THE NERVE SUPPLY . REFINEMENTS OF TECHNIC IN INJECTING . SUPERFICIAL INFILTRATION AND DEEP BLOCKING . POINTS IN OPERATIVE TECHNIC . PRECAUTIONS . TECHNICAL POINTS IN LIGATION . CONTROLLING PSYCHICAL REACTIONS . ADVANTAGES . THE TREATMENT OF GOITER WITH QUININ AND UREA INJECTIONS . GENERAL OBSERVATIONS CASE RECORDS . TREATMENT . RESULTS AND CLINICAL CONCLUSIONS .

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LEIGH F WATSON, M. D. — RUSH MEDICAL COLLEGE — CHICAGO, ILL.

SPEAKING BEFORE THE New Orleans Parish Medical Society, September, 1918, Carroll W. Allen of New Orleans, La., described in detail his latest technic for thyroidectomy under local anesthesia. In his discussion he dealt principally with exophthalmic goiter, as the operative technic of the simple colloid goiter under local anesthesia presents no especial difficulties, and the steps are identical in the two types and it is only when a colloid goiter is unusually large that Allen considers any variation in the technic necessary. Pursuing his subject Allen maintains that:

To satisfactorily and intelligently operate under local anesthesia we should first become thoroughly familiar with the source and distribution of the nerve supply of the region. This is one of the fundamental factors of success, as I have often said before in discussing these subjects, local anesthesia makes of us nerve anatomists.

THE NERVE SUPPLY.

THE SKIN OF THIS region is supplied by the superficialis colli nerve formed by branches from the second and third cervical, which emerges from behind the posterior margin of the sternomastoid muscle and curves forward just above the point where the external jugular vein passes over this muscle, and, passing forward beneath the jugular and platysma muscle, divides into branches which supply this muscle and the skin of the anterior region of the neck from the chin to the sternum.

Beneath the area of distribution of this nerve we come to that supplied by the loop formed by the decendens hypoglossi and the conjoined branch from the second and third cervical nerves, which descend from the upper part of the neck upon the carotid sheath and supplies the sternothyroid, sternohyoid, both bellies of the omohyoid and the anterior surface of the thyroid gland.

The third and last source of nerve supply is that to the under surface of the thyroid gland; this is from the deep branches of the cervical plexus, from the nerves that supply the longus colli rectus lateralis and other prevertebral muscles.

These nerves are all small branches and pass forward to the under surface of the gland.

REFINEMENTS OF TECHNIC IN INJECTING.

THIS COMPLETES THE nerve supply of the region, and we should now be able to intelligently proceed to block off this region quickly, methodically and with a minimum of anesthetic solution. Should discomfort be complained of at any point we should be able to determine its source by the depth at which we are working and relieve it immediately by additional injections at the indicated point, and not by aimlessly injecting in all directions in hopes of catching the offending nerve.

In discussing the injection of any region, it is understood that certain refinements of technic should be made use of, such as establishing an intradermal wheal with a fine needle at any point at which a larger needle may be entered for deep injections, and in very sensitive patients the skin may be frozen before making this first wheal. Also, in making deep injections or advancing the long needle through the tissues to any desired point, to progressively inject the solutions as the needle is being advanced.

Knowing our nerve supply, we can now proceed intelligently to block off the operative field. For the skin, we have the choice of two methods, both of which I make use of.

SUPERFICIAL INFILTRATION AND DEEP BLOCKING.

WE MAY BLOCK the superficialis colli where it curves over the sternomastoid by passing a long needle down to the deep fascia over this muscle, just behind the point where the external jugular passes over this muscle, and directing the needle upward in the long axis of the muscle, injecting this area freely for about one and one-half inches, using about 5 to 10 cc. of solution. This injection, when properly made, will reach all branches of this nerve and give us a superficial anesthesia down to the deep fascia and extending almost from the chin to the sternum. The same procedure is repeated on the opposite side.

The other method of superficial anesthesia, and the one more commonly used, is to make a fairly free subcutaneous injection along the proposed line of incision. This is best done by making a skin wheal in the mid-line of the neck and, entering a long needle at this point, injecting first to one side then withdrawing the needle and directing it in the opposite direction.

Having satisfactorily anesthetized the superficial parts, we now turn our attention to the deeper parts supplied by the loop formed by the descendens hypoglossi and second and third cervical. It will be seen, by considering the course and distribution of this nerve, that it can be effectively blocked by an injection made down to the carotid sheath, above the field, in the lower part of the superior carotid triangle, entering the needle just above the omohyoid muscle and making the injections just beneath the deep fascia, when it will diffuse in all directions, reaching the nerves as they come downward and forward. For this purpose, the long needle is entered near the outer extremity of the subcutaneously infiltrated area, should this method have been used, or, if the superficialis colli has been blocked, at any point near the lower part of the superior carotid triangle. As the needle is advanced down to the carotid sheath, the solution should be injected continuously as the needle is being advanced. If the needle is of small caliber, with sharply beveled point, no damage should result from contact with a vessel. It is however, a good precaution, when making an injection in the neighborhood of large vessels, to aspirate slightly before making the injection, to determine whether or not a vessel has been entered. This injection, when properly made, is free from danger, but the operation may defer this step until this skin flap has been raised, which gives a slightly closer approach to the area of injection.

Having made the skin incision and retracted or divided the thyroid group of muscles, as may seem necessary, the anterior surface of the gland is thoroughly exposed, permitting the needle to be passed under its lateral edge at two or more points, infiltrating the cellular tissue behind the gland, thus reaching the deep group of nerves to its posterior surface.

POINTS IN OPERATIVE TECHNIC.

THIS COMPLETES THE anesthesia, and the enucleation or resection of the gland can now be proceeded with by any method preferred by the operator. Its posterior capsule and a small piece of the gland, about one-sixth or one-eighth of its total, should always be left in place, for obvious reasons. For my own part, I always prefer to divide the isthmus first when operating under local anesthesia, and roll the gland out away from the trachea, thus avoiding the repeated disturbance to this part from traction on other parts of the gland, which is always quite disturbing to the conscious patient. Another advantage in dividing the isthmus first is that the gland can be rolled outward and lifted from its bed with more facility, as it is unattached at any other points except by vessels and fascia, and, as the gland is lifted up, the vessels on its under surface can be readily seen and ligated, and the danger to the recurrent laryngeal nerve greatly lessened.

PRECAUTIONS.

THIS SUBJECT IS never complete with a simple discussion of the operative technic, as there are other things to be considered. It is not advisable to operate upon all cases, and some operations have to be performed in stages. Very severe cases, when suffering from edema, ascites, dilated heart, diarrhea, gastric crisis of vomiting and other visceral disturbances, should not be operated at once, but kept under observation, with rest, ice bags and other indicated treatment, waiting for a lull in the symptoms. Many of these severe cases have suffered permanent injury to the heart, kidneys and other organs. It is consequently always desirable to operate as early as possible in all cases which do not yield to medical treatment.

It is doubtful if severe cases should ever have the complete radical operation of double resection or lobectomy done at one time, but it is safer to do one side at a time, allowing one or two weeks for recovery, when the other side may be done.

In quite severe cases, too sick to attempt the radical resection of a part of the gland, but yet capable of standing a limited amount of surgery safely, we can often accomplish a decided abatement of the symptoms by ligating one or both poles of the gland. This, when properly done, often accomplishes much good and allows the patient to recover sufficiently to permit the resection of a lobe.

TECHNICAL POINTS IN LIGATION.

TO PROPERLY LIGATE the thyroid pole, an incision can be made across the neck at the proper level, or I often prefer an incision on the inner side of the sternomastoid, exposing by blunt dissection the pole of the gland, when a silk or linen ligature on an aneurysm needle is passed around the upper extremity of the lobe embracing arteries, veins, nerves and a small portion of the tip of the gland, tying the ligature quite firmly. Catgut is objected to for this purpose, as it may be absorbed too early. The vessels should not be dissected out and ligated singly, nor should the ligature be placed above the pole of the gland, if the best results are to be accomplished, as the anastomosis between the vessels of the upper and lower pole is quite free, and unless done in the proper way the circulation is compensated quite early and our object defeated. Much improvement often follows this ligation, and in some cases the improvement is so marked that the patient objects to further operative intervention; but this is a serious mistake, and advantage should be taken of this lull to perform the resection, which should be done in from one to two or three weeks following the ligation.

CONTROLLING PSYCHICAL REACTIONS.

THE PSYCHICAL EFFECT of any operative procedure upon these cases is often considerable, and they suffer acutely from fear, which increases the blood pressure and heart acitivity, thus greatly stimulating the activity of the gland and increasing all the toxic symptoms. It is consequently better to keep these cases in the hospital a few days before operation, not letting them know exactly when it will be performed. During this time they should be kept absolutely quiet in bed, free from visitors and other disturbances, with an ice bag continually to the neck, avoiding meats, coffee, alcohol and all stimulants in diet. As these patients have absolutely no control over their emotions, and as fear is largely a psychical manifestation, it is highly desirable to control the psychic functions by a large dose of some opiate before going to the operating room. I do not like morphin in these cases, as it sometimes excites them and does not exert any hypnotic influence; scopolamin is also objected to for similar reasons. Pantopon, representing the entire active principles of opium, makes the ideal hypodermic, using from one-half to two-thirds of a grain about one hour before the time set for the operation. This dose is sufficient to render the patient dull, apathetic, and inclined to sleep when left alone; the patient is thoroughly conscious, but just enough under the control of the drug to be listless and indifferent—an ideal state for operation, when it is highly important to have under control all psychical disturbances: These are the essential points in the surgery of this condition under local anesthesia.

ADVANTAGES.

ITS ADVANTAGES ARE MANY. When handling these cases in this manner, the danger is greatly lessened, general anesthetics favoring edema of the lungs, and renal suppression in bad cases, and by the vascular congestion which they induce, greatly increase the toxic activity of the gland. With local anesthesia, which is now used always in conjunction with adrenalin, we have the opposite condition, ischemia, which greatly lessens the activity of the gland, and especially at the time when it is desirable to have it under control. The recovery following operation is greatly facilitated when done under local anesthesia, as the patient can at once begin to take water freely to flush out the emunctories and more rapidly relieve the toxicity.

Before closing, I would like to call attention to the enlargement of this gland, which often occurs in young girls about the age of puberty, before the menstrual function has been regularly established, and is often associated with mild toxic symptoms. In these cases we should not operate too hastily, as the condition will usually subside under proper treatment directed to the regular establishment of the menstrual function.

MANY EFFORTS HAVE BEEN MADE in the past to find some means of treating thyrotoxic goiter without subjecting these hazardous risks to surgical intervention either under general or local anesthesia. When it was found that solutions of quinin and urea would diminish the size of angiomas after injection, it occurred to Leigh F. Watson of Chicago, Ill., to try out the effects of similar injections in exophthalmic goiter. Writing in Medicine and Surgery, 1918, Watson thus recounts his experiences in introducing and using the method:

About five years ago I observed the effect of a concentrated solution of quinin and urea which I injected into an angioma of the tongue, that had been repeatedly cauterized with carbon dioxid snow without reducing its size or vascularity. Injections of a 50 per cent. solution caused the tumor to disappear completely; the tongue assumed its normal size and color and there has been no return of the condition since.

Shortly after treating the angioma, I used the quinin and urea injections in a severe case of toxic exophthalmic goiter. The patient was too ill to stand even the slight operation involved in ligating the superior thyroid arteries; the improvement following the injection was more decided than I had even seen following ligation.

Injections of iodin, carbolic acid, alcohol, arsenic, iodoform and chromic acid are to be condemned because of their poisonous and corrosive properties and the liability of producing an embolus if accidentally injected into the blood stream. The harmlessness of quinin and urea intravenously is well known; in some localities it is the treatment of choice for certain types of malaria.

GENERAL OBSERVATIONS.

IN THE TREATMENT of goiter, as in the treatment of many maladies, the surgeon urges that the patient be recommended for operation early. No doubt the best results do follow the operation when it is performed before the disease has reached the more serious secondary stage,—just as a smooth and comfortable recovery will often follow the proper medical treatment when administered to beginning cases. It is not my purpose to condemn the operation for goiter. Anyone with experience in the treatment of the disease cannot doubt its value as a therapeutic procedure, and in many cases it is the only means from which the patient may derive benefit. It is my opinion, however, that only in exceptional cases should it be the first step taken to effect a cure. The mortality is high; the recurrence is frequent; and until a greater number of patients have been cured by it, and until a longer period has elapsed since it came into use, there will always be the question as to whether the patient operated upon, may not suffer at a later time from too little thyroid function. It has been less than twenty years since the operation of partial thyroidectomy for exophthalmic goiter came into general use.

It is a well-established fact that the thyroid begins to shrink and its activity decreases after the thirty-fifth year; if too much of the gland is removed early in life, it is reasonable to believe that disturbing symptoms of hypothyroidism or myxedema are liable to appear at middle age, with increased susceptibility to infections and disease.

I believe it is possible to destroy a smaller amount of thyroid tissue by quinin and urea injections than is usually removed in the ordinary operation of partial thyroidectomy—the symptomatic relief is the same; statistics show that the recurrence is lessened; and the method is without the danger of the operation. It is a question whether the portion of the gland remaining after lobectomy, is any better able to maintain bodily functions than if a lesser amount is destroyed by injections, cautiously given, so that the greatest amount of gland, compatible with the restoration of health, may be saved.

The studies of Wilson[1] have definitely proved the constant association of exophthalmic goiter with primary parenchymatous hypertrophy and hyperplasia of the thyroid gland. Kendall[2] has isolated from the thyroid of exophthalmic goiter an active principle, *Substance A*, which when injected into a normal person increases pulse rate, vigor, metabolism and nervous irritability; a very small amount will produce marked symptoms of hyperthyroidism. He also observes that in exophthalmic goiter the secreting capacity of the gland is greatly increased and the reservoir capacity much decreased.

Bearing in mind these pathological changes which accompany exophthalmic goiter, it is obvious that medical treatment which stops short of destroying a portion of the enlarged and hyperactive gland, will at times fail to afford relief from the active symptoms and will also fail to prevent recurrence when the hypersensitive, although quiescent goiter is subjected to severe strain, such as worry, grief, fright, parturition, climacteric, infectious diseases and operative shock.

CASE RECORDS.

I HAVE RECENTLY REVIEWED the case records of 125 patients who came from localities where goiter affects not over 15 per cent. of the population. It is interesting to note that the age of onset in both the toxic and nontoxic types, is later in life than in sections where the disease is more prevalent. Of this group, 45 were toxic exophthalmic and 80 were nonexophthalmic. Of the latter, 52 per cent. were toxic and 48 nontoxic. In 43 per cent. no exciting factor could be elicited; in the remaining 57 per cent. the onset of the goiter was ascribed to a definite exciting cause.

Goiter usually begins in the right lobe; sometimes in the isthmus, and least frequently in the left lobe. Both lobes and isthmus are almost always involved before it becomes markedly toxic.

1. Wilson: The Relation of the Pathology and Symptoms of Simple and Exophthalmic Goiter. (Jour. Amer. Med. Assoc., 1914, Vol. lxii, pp. 111-112.)

2. Kendall: Isolation of Iodin Compound in Thyroid. (Jour. Amer. Med. Assoc., 1915, Vol. lxiv, p. 2042.)

TREATMENT.

THE NECESSITY OF minimizing the slight pain from any intrathyroid injection, by means of local anesthesia, cannot be too strongly emphasized. Preliminary injections into the thyroid gland of a few minims of sterile salt solution, followed by injections of sterile water, are necessary to raise the patient's threshold to stimuli, thereby preventing an acute attack of hyperthyroidism which might otherwise follow the first quinin and urea infiltration. As soon as no hyperthyroidal reaction follows the water injections, their usefulness is at an end.

The strength of the quinin and urea solution varies, depending upon the type of the goiter and character of the symptoms. Only one injection is given at a treatment, which is repeated at two to six-day intervals. Ten to twenty infiltrations are usually required to produce marked improvement in general symptoms. The first injections of quinin and urea are usually given at the upper pole; when the thrill over the superior thyroid artery has diminished, the lower pole is injected, and finally the central portion of the gland is treated. It is important that only a few minims of a concentrated quinin and urea solution be given at each injection, if the object of the treatment is to cause the disappearance of the goiter without a subsequent operation; massive infiltrations are indicated only when the plan is to follow a course of injections by an immediate partial thyroidectomy.

The toxic cases should be watched carefully, and at the first sign of an acute exacerbation of hyperthyroidism, treatment should be stopped, a hypodermic of morphin, atropin and digitalin be given, ice bags applied over the thyroid and heart.

Of course it is realized that all patients must remain in bed during the treatment, and for a period following, under careful dietetic and hygienic supervision—the length of time depending on their progress.

RESULTS.

QUININ AND UREA injections were used in treating 100 of these patients; I believed the method was not suited to the remaining 25.

TABLE I.—EFFECT OF THE INJECTIONS ON THE SYMPTOMS.

	Relieved	Improved	Not Improved
Exophthalmic	...85 (average 4 mos.)	15	0
Nonexophthalmic	84 (average 2 mos.)	10	6

TABLE II.—EFFECT OF THE INJECTIONS ON THE GOITER.

	Disappeared	Reduced	Not Reduced
Exophthalmic	...80 (average 5 mos.)	15	5
Nonexophthalmic	75 (average 4 mos.)	12	13

CONCLUSIONS.

1. THE QUININ AND urea injection has limitations the same as any other treatment for goiter and must be employed only in selected cases. It will not benefit the symptoms in those patients in whom the circulatory and nervous systems have been permanently damaged. The treatment is contraindicated in fibrous and calcareous types of goiter; partial thyroidectomy is the only measure that will remove the tumor in these cases. The treatment of the exophthalmic type in young adults, especially in men, is difficult and should be attempted only under the most favorable circumstances.

2. The treatment is surrounded by certain dangers, immediate and remote. One inexperienced is liable to puncture the trachea or one of the large blood vessels, or to make the injection into the soft tissues of the neck. Injections that are too extensive will produce the same signs of myxedema that follow the removal of too much thyroid by operation.

3. The necessity of minimizing the slight pain of any injection by means of local anesthesia cannot be too strongly emphasized.

4. If the quinin and urea treatment is administered without preliminary injections of a few minims of sterile salt solution, followed by injections of sterile water, attacks of acute hyperthyroidism which might result disastrously, are liable to follow.

5. The gradual improvement of the exophthalmos in certain cases following the quinin and urea treatment points to a nerve control exerted by the thyroid on the exophthalmos.

6. Exophthalmic and nonexophthalmic goiter

occur later in life in non-goitrous localities than in sections where the disease is prevalent.

7. The number of patients cured is highest in the group of those who came for treatment early in the disease; the benefit received by those who came later, was in proportion to the degree of damage done the circulatory and nervous systems.

8. A goiter that has once disappeared has never recurred. A majority of the patients in this group have been under observation for two to five years.

THE SCIENCE OF ANESTHETICS IS ANCILLARY TO SURGERY. THE ANESTHETIST DOES NOT LOOM LARGELY IN THE PUBLIC EYE. WITH FEW EXCEPTIONS HIS VERY NAME IS UNKNOWN TO THE PUBLIC AND HIS SERVICES ARE NOT CAREFULLY SELECTED BY THE PATIENT AND HIS FRIENDS; THE CHOICE IS LEFT TO THE SURGEON OR THE PRACTITIONER IN CHARGE OF THE CASE. IN MANY WAYS A WISE PROCEDURE. THE SURGEON WILL PROBABLY CHOOSE A MAN WITH WHOM HE IS ACCUSTOMED TO WORK AND ON WHOM HE CAN RELY TO PROVIDE THE TYPE OF ANESTHESIA HE DESIRES; THE PRACTITIONER WILL PLUMP FOR THE SAFE MAN, IN WHOSE METHODS HE HAS CONFIDENCE, THE SURVIVAL OF HIS PATIENT BEING HIS ONLY CONSIDERATION. THE PATIENT WRITES THE CHECK AND PROMPTLY FORGETS THE ANESTHETIST'S NAME; HE PROBABLY NEVER CONSIDERS AND CERTAINLY IS NOT IN A POSITION TO KNOW WHAT HE OWES IN SAFETY AND COMFORT TO THE ANESTHETIST'S SKILL. THE ANESTHETIST THEN HAS THREE INTERESTS TO CONSIDER—THE SURGEON'S, THE PRACTITIONER'S, AND THE PATIENT'S. THESE ARE SOMETIMES CONFLICTING AND IT SPEAKS WELL FOR THE ALTRUISM OF THE CRAFT THAT THE PATIENT'S INTERESTS ARE ALMOST INVARIABLY THE FIRST CONSIDERATION. THE EMOLUMENTS OF THE ANESTHETIST ARE NOT LARGE. WHEN ONE CONSIDERS THE AMOUNT OF TIME DEVOTED TO HOSPITAL WORK THEY SCARCELY VIE WITH THOSE OF A GOOD CLASS GENERAL PRACTICE. THE SPECIALTY APPEALS LARGELY TO TWO CLASSES. THE YOUNG MAN WHO SEES IN IT THE SHORT CUT TO THE PURLIEUS OF HARLEY STREET AND THE MAN WHO COMES TO TOWN AND SETTLES IN PRACTICE NEAR MIDDLE LIFE AND SEES IN ANESTHETICS A COMFORTABLE LITTLE ADDITION TO HIS INCOME. OF THESE MANY ARE CALLED BUT FEW ARE CHOSEN. ON THE OTHER HAND THE INTERESTS AND FASCINATIONS OF THE ANESTHETIST'S CRAFT ARE GREAT AND GIVEN A REASONABLE AMOUNT OF FINANCIAL ENCOURAGEMENT INDIVIDUALS ARE TO BE FOUND IN BOTH CLASSES WHO WILL DEVOTE THEIR LIVES TO IT TO THE EXCLUSION OF ALL OTHER AVENUES OF PROFESSIONAL ADVANCEMENT AND IN THE END ACHIEVE A COMPETENCE, PERHAPS EVEN SOME MEASURE OF FAME.

—*G. A. H. Barton.*

ABDOMINAL SURGERY UNDER LOCAL ANESTHESIA . INFLUENCES IN THE CHOICE OF ANESTHESIA . FACTORS IN THE SUCCESSFUL USE OF LOCAL ANESTHESIA FOR ABDOMINAL SURGERY . CONTRAINDICATIONS—PSYCHIC AND PATHOLOGICAL . TECHNIC . COMPARISON OF RECOVERIES UNDER LOCAL AND GENERAL ANESTHESIA . CONCLUSIONS . THE LOW LATERAL INCISION AND METHOD OF NERVE BLOCKING FOR APPENDECTOMY . ANESTHESIA FOR INCISION . ADVANTAGES OF THE LOW LATERAL INCISION . CEREBROSPINAL NERVE BLOCK OF THE MESOCOLON FOR ADHESIONS . LOCAL ANESTHESIA IN CHILDREN . COMPARATIVE ABSENCE OF TOXICITY, FEAR AND NECESSITY FOR RESTRAINT . REFINEMENTS OF TECHNIC IN OPERATING ON CHILDREN UNDER LOCAL ANESTHESIA . PRELIMINARY MEDICATION . STATISTICS OF OPERATIONS . CONCLUSIONS . THE PNEUMATIC INJECTOR AS A SUBSTITUTE FOR LOCAL ANESTHESIA SYRINGES . DESCRIPTION OF THE DEVICE . METHOD OF ASSEMBLY AND USE . CONCLUSIONS.

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IN ADDRESSING THE Minnesota State Medical Association and the West Wisconsin District Medical Society on abdominal surgery under local anesthesia, R. E. Farr of Minneapolis, Minn., assumed that the requirements of the patient are paramount and that all other considerations are of secondary importance. He affirmed that the ideal anesthetic has not yet been discovered. Printing his observations in the Journal-Lancet, June 1, 1917, Farr agrees that ether and nitrous oxid are used most extensively as general anesthetics today, while novocain is the local anesthetic of choice.

Each anesthetic, whether local or general, has its special point of excellence. Many have specific fields of usefulness. Their values are relative, and there is a great variety of opinions regarding the relative values. Methods of anesthesia are much like automobiles and shotguns: while an individual is using a particular brand, it is apt to be the best. This condition is due, in a measure, perhaps, to the fact that experience with one method leads to improvement in its application with gradually increasing satisfaction in its use.

INFLUENCES IN CHOICE OF ANESTHESIA.

THE INFLUENCES WHICH underlie the choice of any particular method of anesthesia are manifold. There is a marked tendency to follow established customs. Sentiment is created at the larger surgical centers, quite naturally, and is rapidly disseminated to the smaller clinics. To break away from established methods that have given fair satisfaction in the hands of those with most experience requires considerable fortitude. It is my belief that the feeling that " if it is good enough for them, it is good enough for me," is often the deciding factor in the choice of an anesthetic, rather than what is the best thing for the patient in each individual case. I believe that it is the custom of surgeons to limit the use of local anesthesia to minor surgery or to cases in which general anesthesia is contraindicated on account of the extreme hazard. If it were possible to so modify the custom in this regard that surgeons would reserve for general anesthesia *only* cases which could *not* be operated on under local anesthesia, it is my belief that great benefit would accrue; therefore, my plea will be for a broader application of local anesthesia, and its more extensive use in major surgery. I shall devote my attention mainly to the technic of its use in abdominal surgery in the belief that calling attention to its application in this field of work will do more for the advancement of this method of anesthesia than will a repetition of the well-known arguments that are usually offered in its favor.

FACTORS IN THE SUCCESSFUL USE OF LOCAL ANESTHESIA FOR ABDOMINAL SURGERY.

THE FIRST QUESTION to be considered is, To what class of cases is local anesthesia limited in doing abdominal surgery? The second is, What are the contraindications to local anesthesia in abdominal surgery?

With regard to work on the abdominal wall, there are no contraindications. With regard to work on any of the movable organs within the abdominal cavity, there are no contraindications. With regard to age, there are no contraindications. With regard to certain forms of disease within the abdominal cavity, there are contraindications that are to be considered later.

Success in this work is dependent on the careful carrying out of certain details which are based upon well-established principles. In all work on the abdominal wall the principles, as far as the anesthesia is concerned, are exactly the same as those employed in the removal of a papilloma or a sebaceous cyst from the skin. After the abdominal wall is incised, there is no essential difference between the performance of an appendectomy, a hysterectomy, a cholecystectomy, a gastrectomy, or an enterectomy. In work on the abdominal wall, a thorough infiltration of the tissues to be incised is necessary. *Ample incision, careful manipulation, vertical retraction,* and an appropriate position of the patient, combined with a judicial use of the anesthetic where needed, will not only result in a large measure of success, but will give the surgeon an opportunity to do the requisite operation within the peritoneal cavity with less trauma and more precision, deliberation, and attention to details than can be done by any other method except that of spinal anesthesia.

The advantages of the sense of sight over that of touch are well recognized by everyone. A proper use of local anesthesia will enable the surgeon to inspect the intra-abdominal organs, in a large majority of cases, in their exact relation to one another before they are disturbed by the manipulation of the surgeon's hand, or the straining which often accompanies general anesthesia. I have often seen surgeons open the abdomen through a McBurney incision, introduce one or two fingers and, after some manipulation, deliver the appendix by traction upon the cecum, and then state to the audience the position in which it was found. Personally, I have never been able so to educate my sense of touch that I could definitely locate the position of the non-adherent appendix with any degree of certainty. It is only since I have been using local anesthesia with *vertical retraction* that I have been able, by the sense of sight, absolutely to locate the appendix in its native haunt. In no other form of anesthesia except spinal can we produce a negative abdominal pressure so that we may open the door and look in.

CONTRAINDICATIONS.

PSYCHIC.—It is my impression that the number of patients who are mentally incompatible with the use of this method is very small, but, undoubtedly, there are some who fall into this class. That there are many such is due more to ignorance and wrong teaching than so-called nervousness or to lack of selfcontrol on the part of the patient. In this connection I might mention the well-known fact that even with the most expert anesthetist restraint is occasionally necessary during the production of general narcosis, especially in children. I have performed laparotomies on children as young as two years, and several on children under eleven, without resort to any physical restraint, although one of these suffered pain during the liberation of a gangrenous appendix.

This psychically incompatible class, small as it is, may be greatly reduced by a careful use of narcotics before operation. Their use is, I believe, not only safe but extremely comforting, and perhaps very beneficial in eliminating that

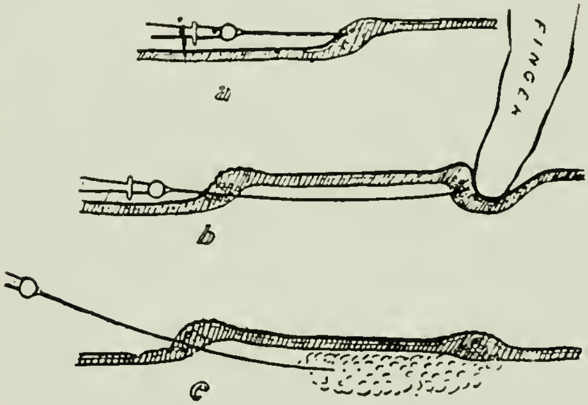


Fig. 1. a. Method of making first dermal wheal. b. Painless subcutaneous method of making secondary wheals, and c. method of subdermal infiltration.

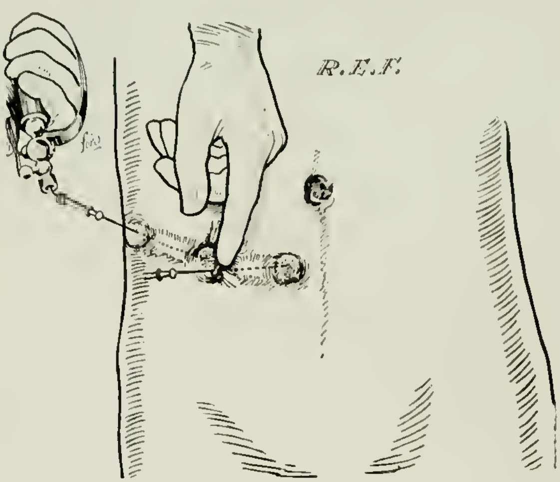


Fig. 2. Abdominal operations. Appendectomy, showing painless subcutaneous method of making secondary wheals.

rather intangible element referred to as psychic shock.[1]

Pathological.—The greatest contraindication to local anesthesia in abdominal work is the presence of disease which necessitates traction on the posterior-parietal peritoneum. The removal of large tumors with broad pedicles, the treatment of disease following peritonitis, and the removal of the gall-bladder may be impossible; however, with a perfect exposure of the conditions and with scissors or knife dissection of the adhesions, the amount which may be accomplished even in these cases is surprising. Where possible, the careful dissection of adherent

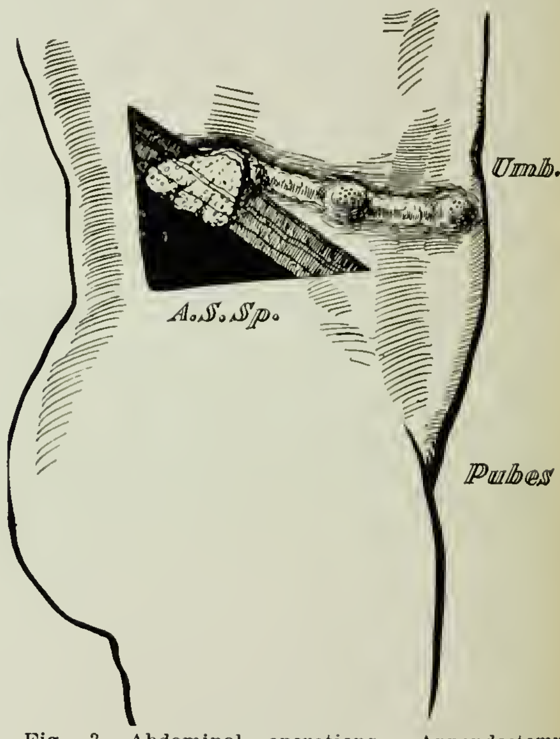


Fig. 3. Abdominal operations. Appendectomy. Diagonal section across line of infiltrated abdominal wall.

masses, thus liberating them before they are elevated, instead of forcible blind enucleation with the finger, greatly lessens the trauma of the patient.

TECHNIC.

IN DETAIL, THE TECHNIC which I have used for the removal of the appendix is as follows: The patient is placed on the table with the right side perhaps three or four inches higher than the left. A pillow beneath the right buttock, or an operating-table which tilts laterally,

1. Farr: "Narco-Local Anesthesia," St. Paul Med. Jour., May, 1916.

answers this purpose. The first wheal is made with the finest hypodermic needle, and is *intradermal*. (Fig. 1, a.) Following this, a three-inch needle is passed through this wheal and advanced *beneath* the skin in the subdermal fat almost its entire length. It is made to impinge on the finger, which makes pressure on the skin until the point has entered the skin from beneath, perhaps two and one-half inches from the original puncture. (Fig. 1, b.) By this method another dermal wheal is painlessly produced. During the slow withdrawal of the needle, the fluid is injected continuously, thus making the subdermal infiltration, which raises the skin perceptibly. (Fig. 1, c.) The needle is then introduced through the second wheal and the process continued the entire length of the incision, or slightly beyond. (Fig. 2.) The needle is then introduced vertically at the first point, and one can easily feel the needle pierce the different layers. While the needle is advancing, the fluid is steadily forced into the tissues, the needle being carried down quite to or even through the peritoneum. (Fig. 3.) This process is repeated along the line of incision until one is certain that the tissues to be incised are thoroughly infiltrated. (Figs. 4, 5.) From two to three ounces of a 0.5 per cent. novocain solution may be used in an abdominal wall of average thickness. With the pneumatic injector this process consumes from two and one-half to three minutes, and subsequent dissection shows an infiltration of the tissues of approximately two inches in width

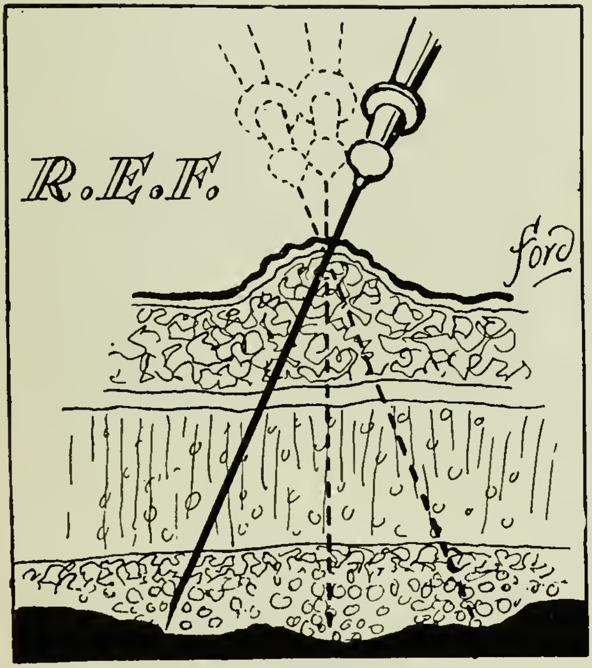


Fig. 4. Abdominal operations. Transverse sectional view of infiltrated abdominal wall.

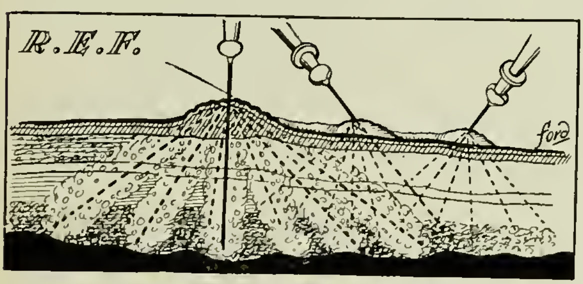


Fig. 5. Abdominal operations. Section of abdominal wall, showing area infiltrated.

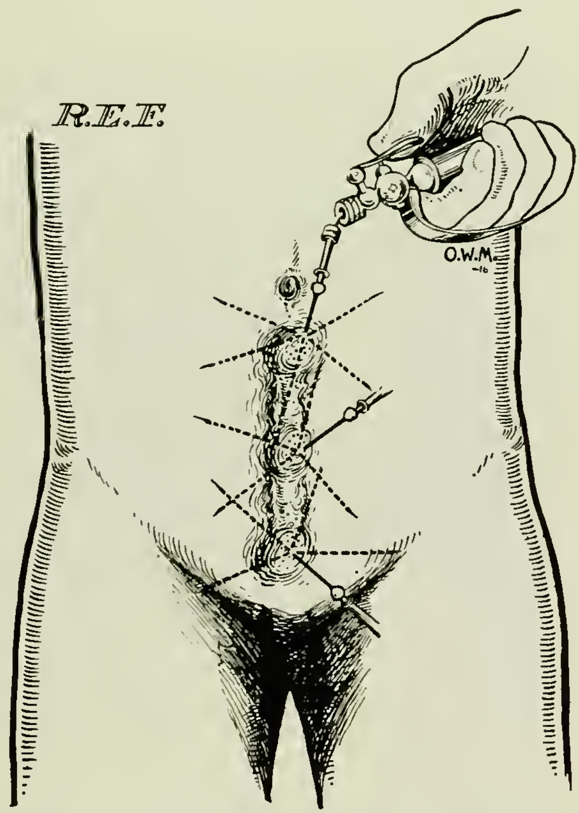


Fig. 6. Abdominal operations (surface view), showing method of making complete infiltration of abdominal wall.

throughout the entire line, as the fluid rapidly disseminates laterally as shown. (Fig. 6.) In about four minutes from the time the injection is begun anesthesia is complete throughout the whole area.

It is my practice to bathe the skin with alcohol as soon as the injection is finished, and immediately to incise the tissues down to the aponeurosis. The abdominal wall is elevated with towel

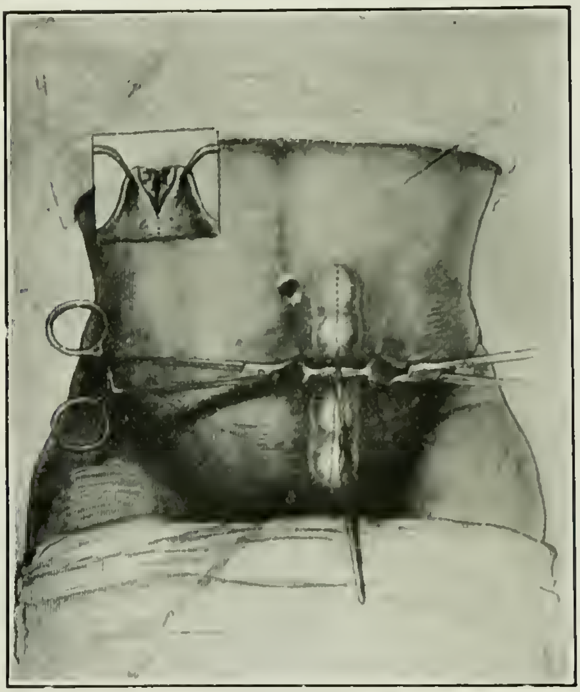


Fig. 7. Abdominal operations. Method of elevating abdominal wall with towel clips while making incision.

clips and then incised. (Fig 7.) While the assistants are placing the protective towels at the edges of the incision, the surgeon's gloves may be washed or changed, and the operation continued without further delay. No more anesthesia is used until the appendix is located. The abdominal wall is retracted *vertically* (Fig. 8), and the table is tilted to the left. Often a slight Trendelenburg position aids in bringing the organs into view. By carefully moving the cecum laterally with the rubber tipped forceps (Fig. 9a) the appendix will come into view in every case in which it is not retrocecal or adherent in the pelvis. While it is held in the rubber-tipped forceps, the meso-appendix is injected with novocain. (Fig. 10.) The appendix may then be picked up and removed in the usual manner. (Fig. 10a.)

During these manipulations it is well to ask

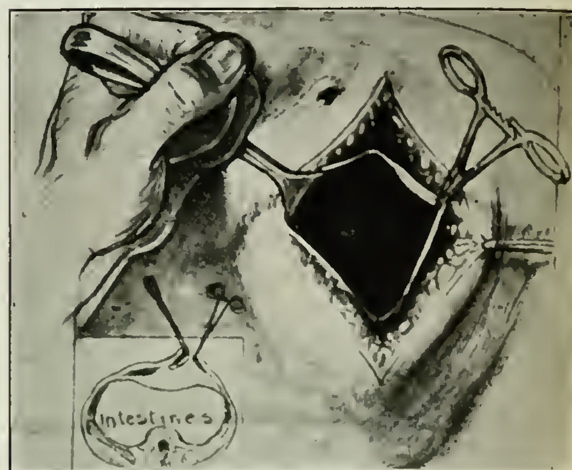


Fig. 8. Shows a close-up view of vertical retraction of abdominal incision.

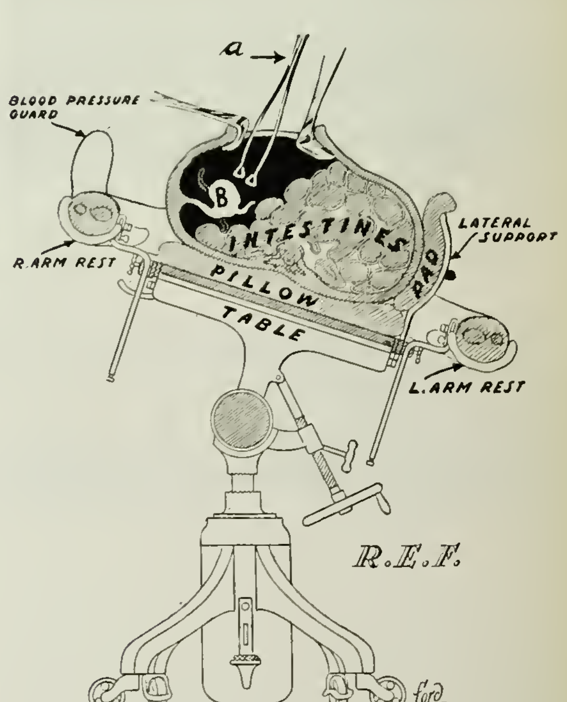


Fig. 9. Abdominal operations. Section of body at appendix level, showing vertical retraction and effect of gravity on intestines. a. Rubber-tipped forceps. b. Cecum.

the patient to open his mouth and to avoid straining, thus reducing intra-abdominal pressure. This is a decided advantage except in operations for hernia, where the sac may be distended at will by the patient and therefore be easily identified. An incomplete anesthesia will almost always result in the patient being compelled to grunt or strain, and so force the intestines out through the wound. With a complete anesthesia and a patient who is at all controllable, this accident is unusual. In a surprisingly large percentage of cases it has been possible to remove the appendix and, in fact, perform other operations without using any pack in order to remove the coils of intestines from the field of operation, gravity alone being sufficient. (Fig. 11.) In some cases of uterine prolapse a preliminary packing of the vagina with the patient in the knee-chest position will eliminate the necessity of painful traction caused by dragging the uterus out of the pelvis. With the sterile electric light (Fig. 12) and *vertical retraction*, the abdominal viscera may be visualized to a surprising extent.

Extreme gentleness and respect for the tissues are our strongest strategic points. As an aid to these I have devised a series of retractors which work automatically and with the least possible chance of tissue-injury.

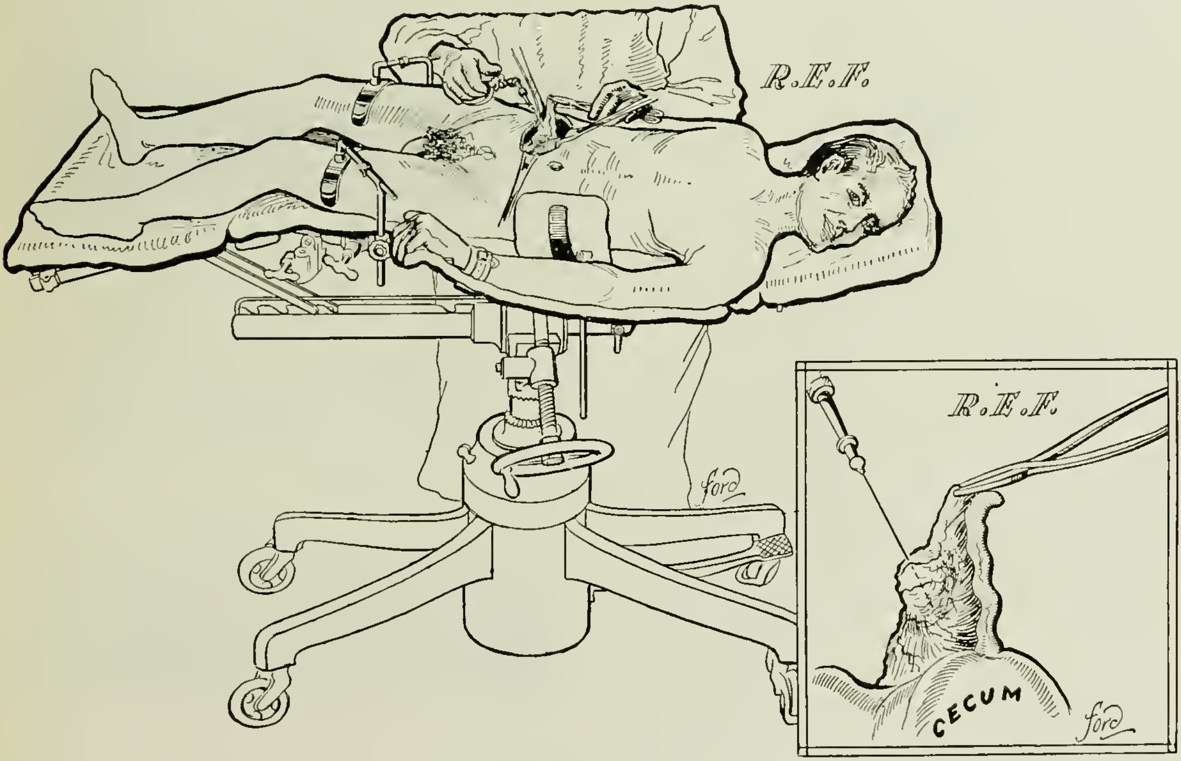


Fig. 10. Abdominal operations, showing lateral tilt of table. Vertical retraction. Insert: Infiltration of mesoappendix.

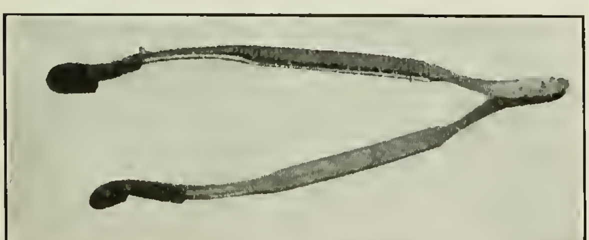


Fig. 10a. Abdominal operations. Rubber-tipped forceps for handling intestines.

COMPARISON OF RECOVERIES UNDER LOCAL AND GENERAL ANESTHESIA.

A COMPARISON OF A series of laparotomies performed under this plan with a series performed under general anesthesia, shows such a difference in the convalescence from the standpoint of anxiety, gas, nausea, vomiting, and thirst that there can be no argument regarding

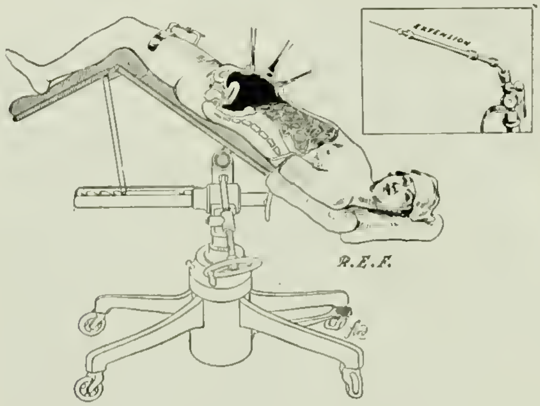


Fig. 11. Abdominal operations. Sagittal section of pelvic laparotomy.

Note the vertical retraction, gravitation of intestines, and perfect exposure of viscera. Insert: Extension used for deep intraperitoneal infiltration.

the merits of the two methods, at least from the viewpoint of the patient. The condition of the laparotomized patient whose sensitive peritoneal surfaces have not been touched during the operation, compared with that of the individual whose abdominal organs have been traumatized by gauze-pressure or manipulation, is so striking as to be impressive. I have removed during recent years many appendices without having touched any portion of the intra-abdominal viscera, except when the cecum was handled by the rubber-tipped forceps or pierced by the suture. Even without the use of quinin-urea many of these cases convalesce as if the abdomen had not been opened. The peritoneal cavity does not realize that it has been invaded.

CONCLUSIONS.

1. The interest of the patient should be the main consideration in the choice of an anesthetic.

2. Novocain is the safest anesthetic known at the present time.

3. The toxicity of novocain depends on the strength of the solution rather than on the total amount used.

4. The use of local anesthesia should not be limited to the *surgical extremes*, but should be extended to a considerable percentage of ordinary major surgical cases.

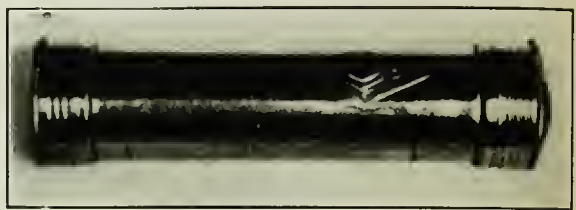


Fig. 12. Sterile electric light.

5. Abdominal surgery lends itself to the use of local anesthesia in a large percentage of cases.

6. With proper equipment and a liberal use of the drug, the time required for operation is not greatly increased.

MANY OPERATORS believe that local anesthesia for appendectomy is adapted only to interval cases in which adhesions have not formed. There are many cases in which the local method cannot be used; however, when it is possible, Watson believes that next to herniotomy, appendectomy is the most satisfactory of the operations of major surgery that are performed under local anesthesia.

Leigh F. Watson of Chicago, presenting his latest observations in the Annals of Surgery, October, 1918, emphasizes that success depends upon a proper incision and the ability to block the cerebrospinal nerves. When the incision is made directly over the base of the appendix, and the cerebrospinal nerves in the mesocolon are completely blocked before any manipulation is attempted, the operation is much easier than when it is done through a McBurney or the lateral rectus incisions of Battle, Kammerer, Jalaguier and Lennander. Watson has used this low lateral incision since 1910, in fifty patients who required removal of the appendix, either as an immediate or interval operation.

ANESTHESIA FOR INCISION.

ANY LOCAL ANESTHESIA operation is successful only when it is painless, and too much emphasis cannot be placed upon the necessity of preventing the least pain in acute appendicitis. In this condition all pressure on the abdomen must be avoided. The initial infiltration of the skin should be preceded by ethyl chlorid spray so that the prick of the needle is not felt. For additional injections and for the division of the different layers of the incision, the tissues should be held up with sharp-toothed anatomical forceps. It is usually advisable to inject the parietal peritoneum for a distance of one or two inches from the edges of the wound before the peritoneum is incised. Sharp scissors will be found preferable to a scalpel for cutting, because the tissues can be divided with the scissors without making pressure on the hypersensitive abdomen.

INCISION.

THE McBURNEY AND lateral rectus incisions are too far removed from the base of the appendix for the local method. To expose the appendix properly through these incisions necessitates uncomfortable retraction on the external oblique and its aponeurosis. Many writers have noted that in the cadaver the base of the normal appendix is found at McBurney's point, while in the living subject it is below this point, usually on a level with the center of Poupart's ligament. A number of operators have called attention to the ease with which the appendix can be removed when operating for right inguinal hernia. If the incision is made directly over the base of the appendix, slight retraction on the edges of the wound will provide a good exposure, and it is less difficult to keep the small intestines out of the way than when the McBurney or lateral rectus incision is used. With local anesthesia, it is not practical to use sponges within the abdomen unless they are required by the presence of an abscess, tympanites, or hemorrhage.

A point one and one-half inches from the right anterior superior spine, on a level with a line connecting the two superior spines, is selected for the beginning of a vertical incision which extends directly downward for two to three inches, to a point just above and to the inner side of the internal abdominal ring. After incising the skin and subcutaneous tissues, the aponeurosis and external oblique are separated in the direction of their fibers by blunt dissection, which exposes the internal oblique. The inner flap is freed from the internal oblique until the linea semilunaris is reached, usually about one-half inch from the opening in the external oblique. At this point the internal oblique muscle and aponeurosis, and the transversalis muscle and aponeurosis, and peritoneum, are incised parallel to the incision in the external oblique muscle and aponeurosis.

ADVANTAGES OF THE LOW LATERAL INCISION.

TRACTION TO EXPOSE the appendix is avoided, because this incision, in the external oblique and its aponeurosis, the most resistant structures, is directly over the base of the appendix. It can easily be enlarged without weakening the abdominal wall. The iliohypogastric and ilioinguinal nerves are not injured because the incision lies between them. Opening the external and internal oblique muscles and their aponeuroses at different levels, preserves the gridiron arrangement of these structures and prevents postoperative hernia. When this incision is used there is also less opportunity for the small intestines to crowd into the wound, than when the higher incisions are employed.

CEREBROSPINAL NERVE-BLOCK.

IN SIMPLE APPENDICITIS when the appendix appears in the wound after the peritoneum is incised, infiltration of the meso-appendix is often sufficient to permit a painless removal of the appendix, providing no traction is made at any time. In the majority of cases it is necessary to proceed as follows: The cecum is grasped gently with moist pledgets of gauze and displaced to one side, usually inward, exposing the mesocolon, which carries the cerebrospinal nerves to the lower part of the ascending colon, secum and appendix. A small quantity of anesthetic solution is injected through a very fine needle at short intervals along the mesocolon for a distance of three or four inches, for the purpose of blocking the cerebrospinal nerves, which are responsible for the sensation of pain that follows traction on the mesentery, and for the separation of adhesions. When the patient states that manipulation and traction are painless, and without the referred epigastric pain which is so characteristic of the usual local anesthesia appendectomy when only the meso appendix is blocked, the appendix is located and delivered into the wound. While anesthesia continues complete, the adhesions are separated, the meso-appendix ligated and the appendix removed in the usual manner. The necessity for gentleness in handling the intestines is important, to avoid

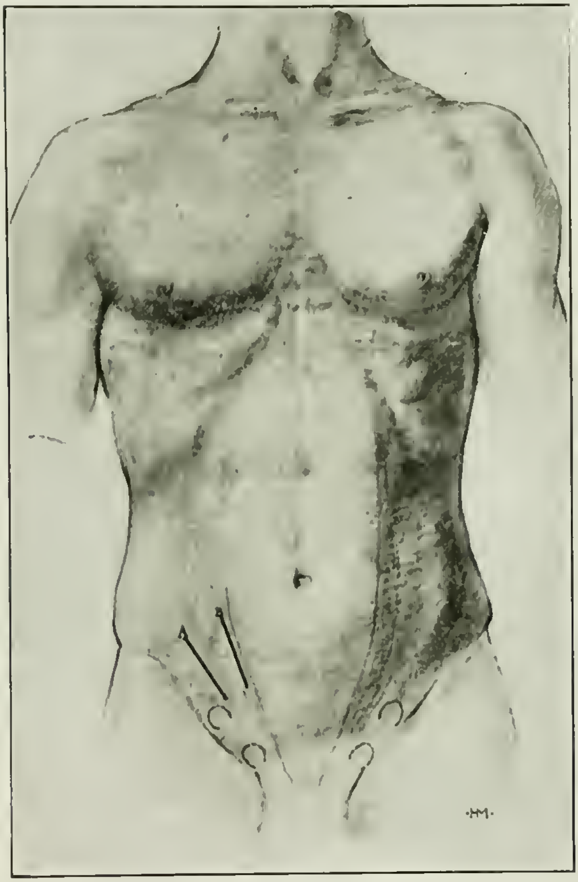


Fig. 1.—Low lateral incision for appendectomy. *A*, incision through skiu, subcutaueous tissues, external oblique and its aponeurosis; *B*, incision of internal oblique aud transversalis.

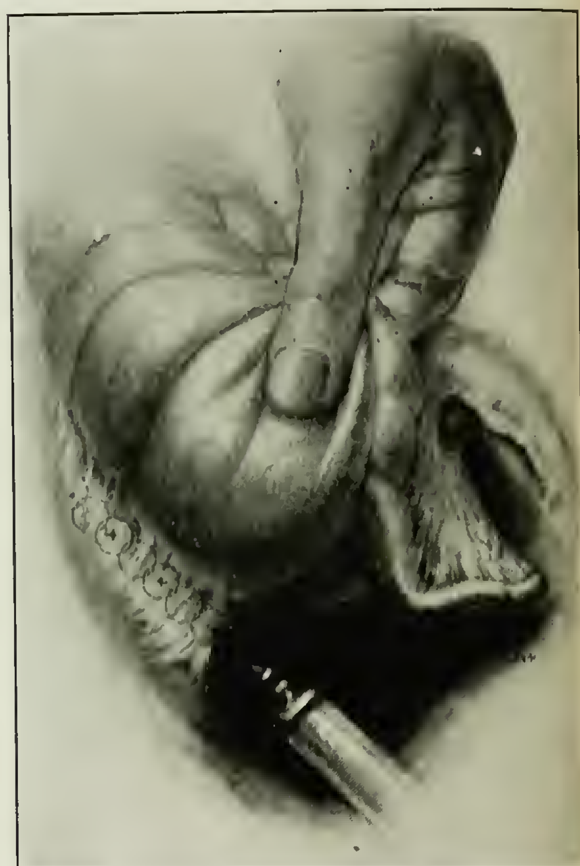


Fig. 2.—Mesocolon nerve block for appendectomy. Method of infiltrating the mesocolon to anesthetize the cerebrospinal nerves supplying the appendix and its mesentery.

accidental traction on unanesthetized portions of the mesentery.

RECOUNTING HIS FURTHER experiences with local anesthesia in the Interstate Medical Journal, 1919, and speaking before a joint meeting of the American Association of Obstetricians and Gynecologists and the Interstate Anesthetists at Cincinnati, O., September 15-17, 1919, R. E. Farr of Minneapolis, Minn., alluded to his surprising success in applying the use of novocain in surgical work on children. Farr illustrated his remarks with a beautiful two-reel film, demonstrating his technic and said in part:

My initial success was so surprising in a child of 18 months, in which an inguinal hernia was repaired, under local, that I have been prompted to continue its use and to apply it in a variety of conditions.

The operations performed have included those upon the head, neck, limbs, external genitals, spine, and abdomen. In all, 77 cases have been attempted with local anesthesia, and in only 10 of these has it been considered necessary to add inhalation anesthesia.

Occasional reports in the literature show that some surgeons have given local anesthesia a trial in children with favorable results, although most authors condemn the method as unsatisfactory. Quite recently La Chapelle[1] reported having done major operations upon children under local anesthesia, and he views the method with approval. Haggard,[2] in a paper on Congenital Hypertrophic Stenosis, states that novocain is the anesthetic of choice in children with this affliction, though he does not mention the number operated upon by him by this method.

In June, 1917, at the New York meeting of the American Medical Association, I reported having performed successfully with novocain, a number of operations upon young children, and showed a motion picture of a boy of 5 years undergoing an operation for inguinal hernia. All steps of the operation were shown, the lad amusing himself the while by drinking buttermilk and *making faces* at the nurses and the *picture man.*

COMPARATIVE ABSENCE OF TOXICITY FEAR AND NECESSITY FOR RESTRAINT.

THERE IS NO REASON to doubt that, relatively speaking, novocain is as safe in the child as in the adult. Moreover, the psychic element is less troublesome. To be sure, these little patients may be frightened at their new surroundings, and all very young ones have to be restrained by mechanical means (Fig. 1) until they learn that they are not to be hurt; but we very early learned that the restraint necessary during the introduction of novocain did not compare with that ordinarily found necessary when general anesthesia was being administered. A majority of those above 4 years of age submitted without mechanical restraint. Many of them, as soon as they found that they were not to be hurt, began to *show off* and exhibit clever stunts, of which they were proud. Bribes of various kinds have been used as bait for good behavior, and the results achieved along these lines are gratifying. Candies, money, and toys are especially effective. A prize of $1 offered to a boy of 4 took him through an operation for inguinal hernia and the excision of a hydrocele sac without shedding a tear. The only one of this group who suffered postoperative vomiting was a case of hypertrophic pyloric stenosis, and here vomiting was late and had no relation to the anesthesia *per se.*

REFINEMENTS OF TECHNIC IN OPERATING ON CHILDREN UNDER LOCAL ANESTHESIA.

IN WORKING UPON CHILDREN the same refined technic is required as that found

1. La Chapelle, E. H.: Nederlandsch Tijdschrift voor Geneeskunde, Amsterdam, December 9, 1916, p. 2085.

2. Haggard, Wm. D.: Jour. Am. Med. Assn., Vol. lxxi, No. 10, p. 810.

necessary in working upon the adult. Sharp dissection and careful traction and manipulation must be adhered to. Abdominal work requires anesthesia which results in *negative intraabdominal pressure. Vertical retraction* and *tilting* of the *body* are used to bring the organs into view.

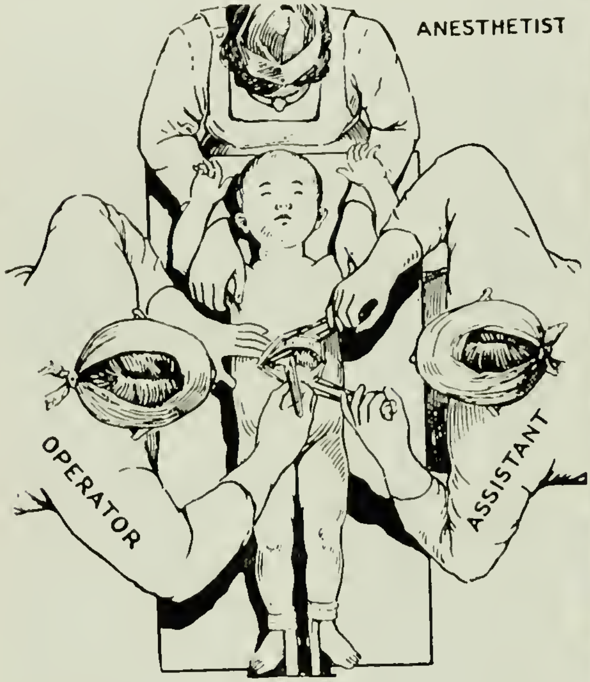


Fig. 1.—Illustrating the method of controlling young children in operations under local anesthesia. By making traction on the arms, the anesthetist controls the child when necessary.

Just as in the adult, protrusion of the abdominal viscera through the incision is to be looked on as evidence of incomplete anesthesia if it occurs in the absence of vomiting or (in the case of children) crying. In the adult no packing should be required to prevent this protrusion of the abdominal contents. This is especially true with lower abdominal incisions. In the child one must guard against this protrusion in case the patient should begin crying. A sponge must be kept ready for this emergency, and, should it arise, used to prevent evisceration—not by packing gauze into the abdomen, but rather by plugging the opening temporarily. By applying towel forceps to the edges of the incision, the abdominal wall may be elevated gently and the abdominal contents examined visually to a degree seldom found possible under general anesthesia. The flaccid abdomen resulting from a perfect local anesthesia gives one a condition almost like that found at autopsy. The constant motion of the

Fig. 2. (1) Florence D., aged 12 years. Grattan osteoclast in place, refracturing malunited femur. (2) Wallace W., aged 13 years. Undergoing operation for undescended testicle and hernia. (3) Babe G., aged 3 weeks. Hypertrophic pylorus stenosis. Directly after operation.

viscera seen so commonly under general anesthesia is almost entirely absent. This is especially true in the absence of distention or acute inflammation. In acute conditions where abdominal distention is marked, as in acute appendicitis, or intussusception, narrow gauze packs can be inserted with slight inconvenience, provided the abdominal wall is anesthetized over a wide area, so that vertical retraction can be made without pain.

Operative procedures on a child must be carried out in a manner which might be appropriately designated as *stealthy*. Failure may follow any overt act which violates the more or less clearly defined routine one must follow. For instance, I have found that the hasty or careless introduction of a retractor by an assistant who was not conversant with the method has caused a sharp contraction of the abdominal muscles, with a consequent extrusion of the intestines. This emergency necessitated the administration of ether in a boy of 4 years, upon whom I was operating for inguinal hernia, and who, up to

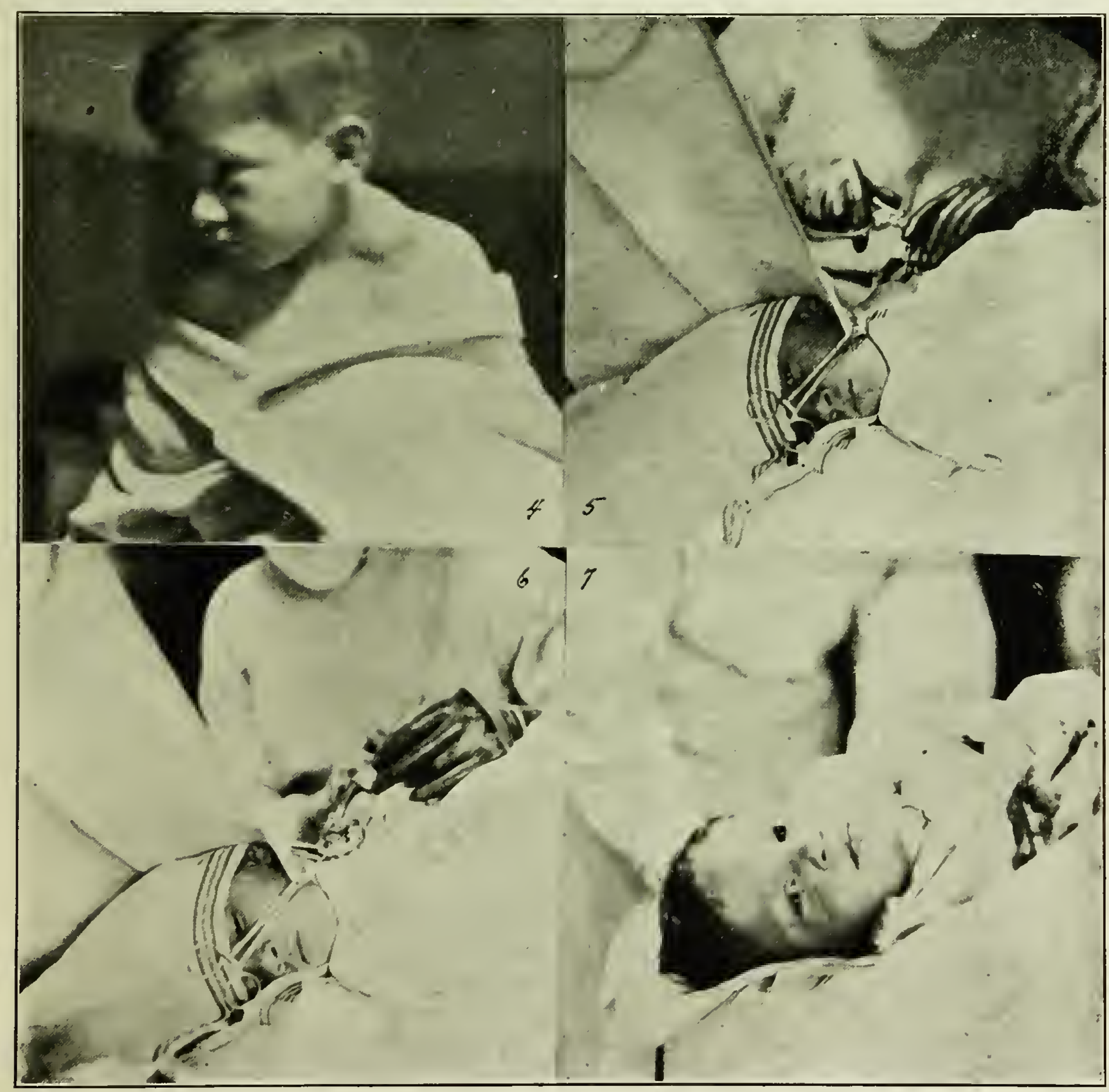


Fig. 3. (4) Andrew W., aged 4 years. Enlarged cervical glands. Complete dissection of the left side was done. Before operation. (5) Injection being made. (6) Mass of glands the size of a man's fist delivered. (7) At finish of operation.

the time that the assistant *gouged* him with the retractor, had not even needed restraint and had not made any outcry.

Another frequent cause of trouble is due to the assistant allowing the retractor to slip out of the wound. Such an accident will also cause a sharp contraction of the abdominal muscles, and should be avoided. In children most of the retraction is done by automatic wire retractors, or towel clamps, which eliminate these difficulties to some extent.

PRELIMINARY MEDICATION.

PRELIMINARY HYPNOTICS have been tried—paregoric in infants and pantopon hypodermically in older children—but the dosage and effects are so uncertain that little benefit is to be expected from this source, and they are, probably, unnecessary. In children, as in adults, it is our practice to make the complete infiltration before beginning the operation. We consider that we have made an error in technic, provided it becomes necessary, in the operation for hernia for instance, to inject the deeper layers after the skin incision is made. Even the blocking of nerves, as they present, is usually unnecessary, although it may be well to take this precaution.

The most important point, aside from the above, is the avoidance of pain in making the infiltration. This is done by making all secondary wheals from beneath, and by making subdermal rather than intradermal injections for the anesthesia of the skin. The deeper infiltration is to be made slowly and methodically under a constant, even pressure. Whereas in adults the needle may precede the outflow of the novocain, in children the fluid should advance into the tissue just ahead of the point of the needle. The area to be blocked should be *soaked*, or in other words, completely saturated with novocain. If this is done, there is no margin of error as to obtaining anesthesia.

A simple method of restraining the child is illustrated in Fig. 1. In most cases of very young children we have used the *arm table* as an operating table, with the operator, assistant, and anesthetist sitting down.

STATISTICS OF OPERATIONS PERFORMED.

THE FOLLOWING OPERATIONS have been performed upon children under 15 years of age:

	Operations under novocain.	Changed to general anesthesia.
Appendectomy:		
Under 10 years of age	5	3
Between 1 and 15 years of age..	8	3
8 of these were acute, 5 were chronic.		
Inguinal hernia—radical operation:		
Under 10 years of age	6	..
Between 10 and 15 years of age..	4	1
Cryptorchidism—transposition of testicle:		
13 years of age................	1	..
Hypertrophic pyloric stenosis—Ramstadt operation:		
3 weeks old	1	..
6 weeks old	1	..
Spina bifida—closure:		
2 days old	1	..
2 months old	1	..
Macropedia—amputation of portion of foot:		
16 months old	1	..
Circumcision:		
Under 10 years of age	7	..
Between 10 and 15 years of age..	5	..
Tonsillectomy:		
Between 12 and 15 years of age..	3	..
Fractures:		
Under 10 years of age..........	3	..
Between 10 and 15 years of age..	5	1
Removal of bursæ, cysts, ganglion, nevi, and suppurating glands:		
Under 10 years of age	5	..
Between 10 and 15 years of age..	5	..
Cleft palate:		
15 years of age................	1	..
Dissection of neck for removal of enlarged glands:		
4 years of age.................	1	..
Between 10 and 15 years of age..	3	..
Osteomyelitis of tibia—Beck's operation:		
11 years of age, two operations..	2	..
Erb's paralysis—excision of scar and suture of nerves:		
3 months old	1	1
Arthroplasty of hip:		
14 years of age................	1	1
Hydrocele of cord:		
4 years of age.................	1	..
Empyema—rib resection:		
6 years of age.................	1	..
Trephining—for fractured skull:		
3 years of age.................	1	..
Trephining—for brain tumor:		
11 years of age................	1	..
Tendonplasty of hand:		
14 years of age................	1	..
Osteoma ulna—excision with chisel:		
11 years of age................	1	..
	77	10

CONCLUSIONS.

1. The psychic element is not so important in children as in adults when operating under local anesthesia.

2. Less restraint is necessary during the administration of local than during the administration of general anesthesia.

3. Much more tact and a more refined technic are required in operating upon children under local than under general anesthesia.

4. The margin of safety possessed by novocain over geneial anesthetics is as great in children as in adults.

5. A large percentage of bad risks should have the benefit of this margin of safety.

6. More extensive application of novocain in the surgery of children is indicated, and, if a more common use of this drug obtained in this class of cases, the science of medicine as well as the art of surgery would be benefited.

THE PNEUMATIC INJECTOR, writes R. E. Farr of Minneapolis, Minn., in the American Journal of Surgery, Anesthesia Supplement, 1918, is designed to replace the syringe in making infiltrations for local anesthesia. In order to compete with general anesthesia, local anesthesia must be administered with greater speed and less labor than has been possible heretofore with the ordinary equipment.

The elements of time and labor necessarily expended have heretofore deterred surgeons in many instances from employing local anesthesia, thus denying patients the great advantages of this excellent method of anesthesia. The pneumatic injector furnishes the surgeon an unlimited amount of the solution, a steady flow under constant pressure, and makes it possible to administer this anesthetic in the minimum time with the minimum output of labor. The constant flow under measured pressure gives one a uniform, even infiltration of the tissues, thus saturating them without tearing them apart as is often the case with a *jerky* syringe, and that most syringes are *jerky* all will agree.

Anyone who has had much experience in the use of local anesthesia knows that the shortcomings of syringes are manifold. They are difficult to keep in order, easily broken, if large, they are difficult to manipulate; if small, they must be refilled innumerable times in doing a major operation, this work often requiring the services of one or more extra nurses. Unless carefully constructed and kept perfectly clean, the pistons do not glide smoothly and do not allow the uniform infiltration of the tissues so essential to perfect

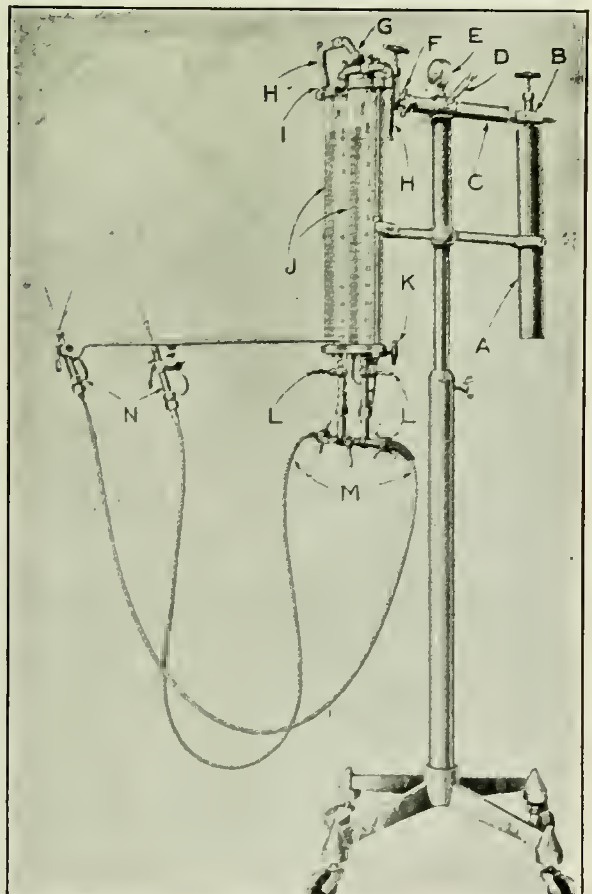
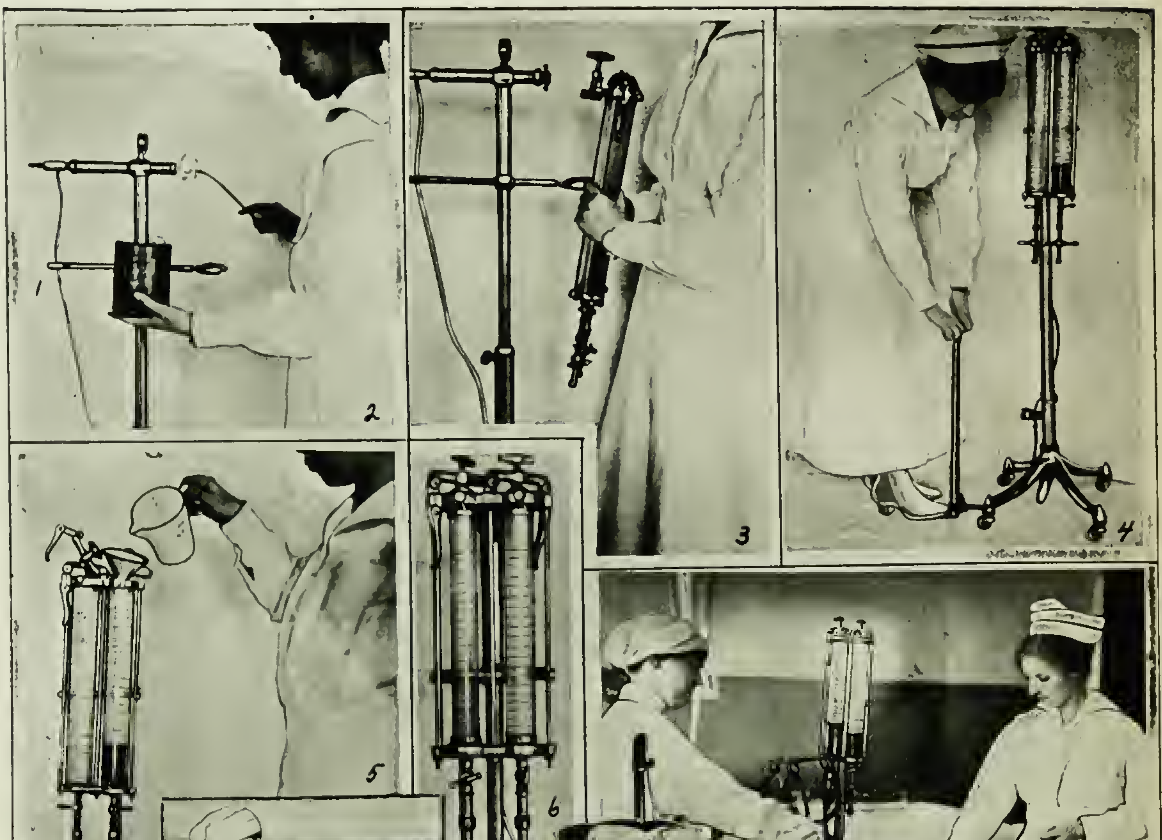


Fig. 1.



Figures 2 to 10.

anesthesia without trauma to the tissues. The introduction of any considerable amount of fluid is slow and exceedingly irksome to the surgeon. The time required by the operating room staff in sterilizing and assembling syringes, and in dissembling, cleansing and drying them after an operation is considerable when much local work is done. The multiplicity of syringes on the market is sufficient evidence that none is satisfactory. If much local anesthesia work is done, the item of expense on account of breakage is important.

DESCRIPTION OF THE PNEUMATIC INJECTOR.

THE PNEUMATIC INJECTOR (Fig. 1) consists of the following parts:

(A) A Prest-O-Lite tank such as is used for inflating automobile tires. The tap for this tank fits into the socket. (B) which is also designed to fit the tap of an ordinary oxygen tank. (An air pump may be used for this purpose.) (C) is a cotton filter. (D) is a safety valve. (E) is a pressure gauge. (F) is a wing-nut which marks the point where the glass cylinders are detacbed from the filter tube. This wing-nut can be loosened and tightened by hand, thus obviating the necessity of special wrenches. (G) represents the removable tops or covers of the glass cylinders. (H) eccentric levers by wbich the tops are securely closed. (I) is an exhaust valve, one of which is placed at the top of each cylinder. Through these the pressure may be reduced before opening the top for any purpose. (J) indicates the glass cylinders which are graduated into ounces and one-fourth ounces. The cylinders are marked *N* and *Q*. respectively, to represent Novocain and Quinin. The glass cylinders are one-fourth inch thick and are specially constructed to withstand pressure. (K) represents the valve through which the cylinders may be drained. (L) represents the valves through which the fluid passes to the tubing. The valves are so arranged that a solution may be directed from either of the glass cylinders through either of the flexible metal tubes, or both of them at the same time. The direction in which the valve is turned indicates the direction in which the fluid will flow. (M) represents the flexible metal tubing tbrough which the fluid passes to the cut-off to which the needle is attached. (N) is the cut-off. It is equipped with a ball-and-socket joint and will accommodate either a screw or a record needle. The ball-and-socket joint allows one to turn the needle in any desired direction. The telescopic rod upon which the cut-off and flexible metal tubing are hung is removed at the end of each operation and resterilized with the tubing and cut-offs.

In order to sterilize the glass cylinders they may be detached at the point *F* and boiled or autoclaved. The cross bar *C* is a tube which is converted into a filter by lightly packing with absorbent cotton (Fig. 2). After sterilizing the cylinders they are attached to the filter by a wing-nut (Fig. 3). We formerly used a compressed air tank, which is exceedingly handy, but at the present time an ordinary pump (Fig. 4) is used as we consider it safer. When all joints are properly tightened, the pressure is maintained for a considerable length of time. The glass cylinders are filled through a sterile funnel (Fig. 5), the adrenalin solution having been previously added to tbe anesthesia solution which insures a good admixture of the adrenalin and the novocain. An exhaust value has been placed at the top of each cylinder so tbat the pressure may be released before raising the covers. Provided cold solutions are not poured into the cylinders when cylinders are hot, there is no danger of breaking them. Once the cylinders are sterile they will, of course, remain sterile for a long time. After the first sterilization by boiling, they may be sterilized chemically from time to time if one so desires. With the instrument covered (Fig. 6) the solutions may be allowed to remain in tbe cylinders for a considerable length of time. For each operation the preparation consists of sterilizing the metal arm (Fig. 7) and the flexible tubing and cut-off with the instruments. After scrubbing up, the instrument nurse places the metal support (Fig. 8) in its socket. She then takes the coiled flexible metal tubing in one hand and with a long artery forceps in the other hand passes this tubing to the anesthetist who attaches it to tbe apparatus by means of a wing-nut (Fig. 8). If much time is to elapse between the settingup of the apparatus and the performance of tbe operation, a sterile drape may be thrown over the flexible tubing (Fig. 9). The anesthetist now arranges the valves *L* so as to direct the fluid through tbe tubing. While being *set up* the apparatus stands near tbe instrument table. After the draping of the patient the anesthetist moves tbe apparatus into a convenient position. The entire extent of the surgeon's labor consists in allowing the air to escape from the tubing. When bubbles cease to come, the needle is attached to the cut-off and the injection proceeds (Fig. 10). The cut-off is equipped with a universal thread so that *screw* or *record* needles may be used. The ball-and-socket joint allows the needle to be directed as one desires. With the extension deep cavities may be supplied without any obstruction to the view. The cylinders have a capacity of from 10 to 16 ounces and are graduated in ounces and one-fourth ounces. One may tberefore appreciate the rate at which tbe anesthetic is being introduced, the anesthetist calling off the number of drachms as the infiltration advances. Cylinders having a capacity of 2.5 oz., graduated into cubic containers have been designated for the use of dentists or nose and throat work where smaller quantities of the solution are required.

Asepsis. Repeated cultures show that the air passed through the cotton filter is sterile. The solution left in the glass cylinders are found by culture to be absolutely sterile in tests made after an interval of more than ten days.

CONCLUSIONS.

AN EXPERIENCE OF five years with various models shows that the principle of the pneumatic injector is correct. In the author's clinic the apparatus has proved so satisfactory that syringes have been discarded entirely. Frequent inquiry has been made concerning the amount of pressure required. Naturally, this depends upon the nature of the tissue which is to be infiltrated, the size of the needle and the speed with which one desires to work. The loose tissues usually require not more than 20 pounds while scar tissue and such tissues as the uterine cervix may require 50 or 60 pounds. With moderate pressure and a rather fine needle the point of which is kept constantly moving, the anesthesia may be administered in less than five minutes in practically every case. As an adjunct to the armamentarium of the operating room, this apparatus has given great satisfaction aside from its use in the administration of local anesthesia. The injection of formalin-glycerin or other solutions where great pressure is required is made with the utmost ease. As an irrigator as well as in the introduction of hypodermoclysis one has always a sterile graduated pair of glass cylinders ready for any use for which they may be required.

IN HOSPITALS THE PREOPERATIVE EXAMINATION OF PATIENTS AND THE CHOICE AND ADMINISTRATION OF ANESTHETICS ARE GENERALLY NEGLECTED. IN THE INSTITUTIONS WHERE AN EXAMINATION IS SUPPOSED TO BE MADE, THE DATA OF THE EXAMINATIONS ARE FREQUENTLY NOT AT HAND AT THE TIME OF OPERATION AND THE PHYSICAL STATE OF THE PATIENT RECEIVES NO CONSIDERATION BEFORE THE OPERATION IS PERFORMED. NO WONDER THAT THE NECESSITY FOR A LAME EXPLANATION OF AN UNEXPECTED FATALITY FREQUENTLY APPEARS. SO LITTLE ATTENTION IS PAID TO THE STANDARDIZATION OF METHODS AND OF APPARATUS THAT NOT ONLY IN DIFFERENT INSTITUTIONS BUT IN DIFFERENT DEPARTMENTS OF THE SAME HOSPITAL WIDELY VARIED METHODS ARE THE ROUTINE. PROPER CONSIDERATION OF THIS TOPIC WOULD SHOW MANY OF THESE METHODS TO BE CRUDE AND UNSCIENTIFIC AND WOULD LEAVE ONLY A FEW WORTHY OF GENERAL ADOPTION. IN MANY CLINICS ONLY ONE AGENT AND ONE METHOD OF ADMINISTRATION ARE AVAILABLE AND MUST BE USED REGARDLESS OF THE NATURE OF THE OPERATION OR THE CONDITION OF THE PATIENT. AT THE PRESENT STAGE IN THE DEVELOPMENT OF ANESTHESIA THE MINIMUM PROVISION IN A HOSPITAL SHOULD BE FOR AN OPEN METHOD OF ETHERIZATION, AN EFFICIENT NITROUS OXID-OXYGEN ADMINISTRATION AND AN INTRAPHARYNGEAL METHOD FOR WORK ABOUT THE FACE. MANY INSTITUTIONS HAVE NOT MANIFESTED SUFFICIENT INTEREST TO PROVIDE EVEN THESE MINIMUM REQUIREMENTS.

—Albert H. Miller.

LAMINECTOMY UNDER LOCAL AND REGIONAL PROCAIN ANESTHESIA . THE NEURO-ANATOMY INVOLVED . METHOD OF MAKING THE INJECTION . SUPPLEMENTAL ANESTHESIA . SURGICAL POINTERS . REGIONAL ANESTHESIA IN EXTRAPLEURAL THORACOPLASTY AND SOME INTRATHORACIC OPERATIONS . GENERAL CONSIDERATIONS OF THORACOPLASTY . SENSORY INNERVATION OF THE THORACIC WALL . INSTRUMENTS . TECHNIC OF INJECTION . RESULTS OF EXTRAPLEURAL THORACOPLASTY IN BRONCHIECTASIS.

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JUST AS IN GENERAL ANESTHESIA, it is often advantageous to use combinations of agents and sequences of method, so also in local anesthesia it is frequently desirable, and more efficient to use local infiltration, nerve blocking and topical application in the same procedure. It is a command of all the methods of administration and a keen insight of their selective use that enables the anesthetist or operator to make local anesthesia complete and entirely satisfactory. These principles are especially valuable in such procedures as laminectomy, extrapleural thoracoplasty and some intrathoracic operations. In this connection, A. C. Strachauer (Journal-Lancet, Feb. 15, 1916) and C. H. Frazier (Trans. American Surg. Ass'n, 1917) have drawn attention to the necessity of using local and regional anesthesia for laminectomy in patients showing evidence of cardiac decompensation, depressed renal function, neurologic pathology, and wasting or exhausting conditions. Krause, Horsley, Cushing, Elsberg, and other neurologic surgeons all comment upon the profuseness of hemorrhage in laminectomies, which frequently is so great as to necessitate the abandonment of the operation or else its performance in two stages. Shock and hemorrhage are the causes of death in laminectomy. But, both factors can be reduced to a negligible minimum under appropriate local and regional anesthesia.

THE NEURO-ANATOMY INVOLVED.

THE ANTERIOR AND posterior roots of the spinal nerves join within the intervertebral foramina. Shortly after the so-formed spinal nerves emerge from the foramina, they send off communicating branches to the sympathetic and then divide into anterior and posterior primary branches. The anterior branches form the intercostal and abdominal nerves; the posterior branches supply the longitudinal muscles and fascia of the back and the periosteum of the vertebræ and innervate the skin to the right and left of the median line. Down to and including the 6th thoracic nerve, the internal branches are mainly cutaneous and the external ones mainly muscular. From the 7th thoracic nerve down, the reverse condition obtains (Piersol). It is the posterior branch that is blocked for the purpose of obtaining anesthesia for laminectomy. Frazier has observed that division of the posterior spinal roots obtunds an area similar in extent to that obtunded by paravertebral injections of procain.

Frazier prefers to inject the parent trunk, the intercostal nerve on the basis of anatomical studies made, at his suggestion, by W. A. Sawyer in investigating alcohol-injections for the relief of intercostal neuralgia.

In order to orientate the intervertebral foramen, the midpoint between the transverse processes serves as the guide. This interval has been estimated as 2.9 cm. to the right or left of the median line. The location of the intertransverse spaces in the thoracic region must be determined by means of palpation, although, in the lumbar region the tip of the spinous process is a little above the lower border of the transverse process of the corresponding vertebra. But, in the thoracic region, having determined the location of one intertransverse process, the location of those above and below is not difficult, since the distance between them is represented as 2.5 cm. and is fairly uniform. The intervertebral foramina in the thoracic region should be reached at a depth of 3 cm., and at a depth of 4 cm. in the lower thoracic and lumbar regions. A matter of real import, Frazier warns, is, the angle at which the needle is inserted. An angle of 45 degrees to the vertical midline or of 35 degrees to the cutaneous surface (Sawyer) is the safe and proper inclination and will prevent the needle from passing into the intervertebral foramen and on into the cord-substance. To determine these angles, measurements may be made with the aid of a protractor. Strachauer and Frazier employ narcothesia preliminary to operating.

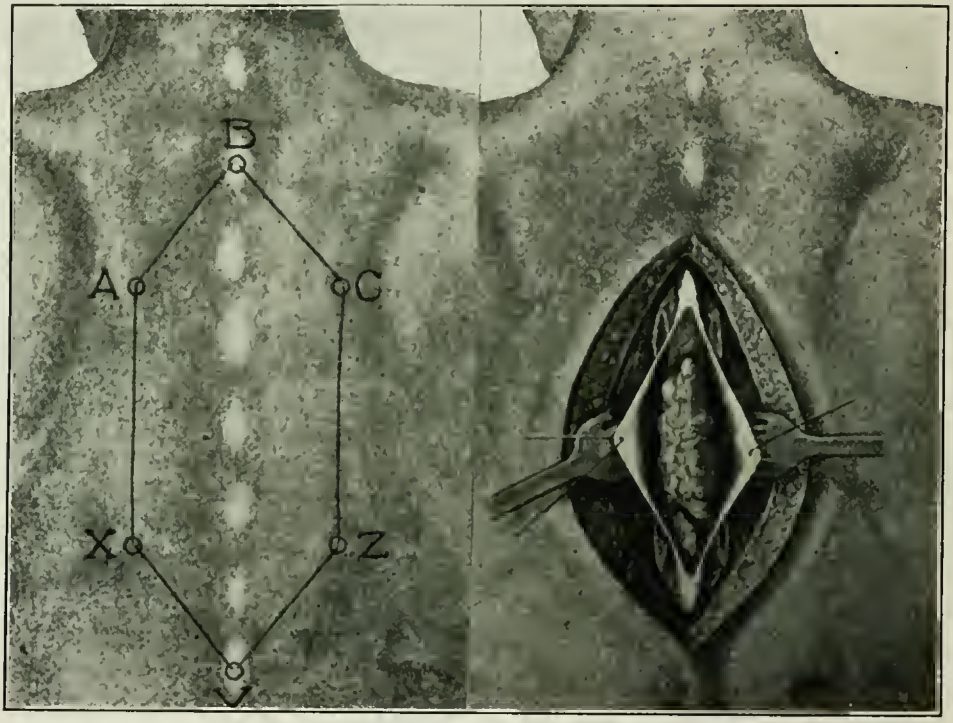

Fig. 1. Field of operation for laminectomy. The hexagon ABCXYZ delimits the area of local anesthesia, produced by infiltration. The posterior primary branches of the several spinal nerves involved are blocked by deep injections as described in the text.

Fig. 2. Small round-cell sarcoma removed by laminectomy under local and regional anesthesia. Pyelonephritis, albumin, casts and pus in urine and myocarditis with displacement of the heart into the right thorax were present in this extremely emaciated and enfeebled patient. The second, third, fourth and fifth posterior vertebral arches had to be removed to permit enucleation of the tumor mass.

METHOD OF MAKING THE INJECTION.

STRACHAUER OUTLINES an ample field of operation by the formation of endermic wheals at convenient points as, *ABCXYZ*, forming a hexagon. The endermic wheal is formed by the injection of a 0.5 per cent, procain solution made through a very fine needle directly into the skin, which latter immediately is rendered anesthetic, thus making subsequent manipulations and injections through the skin painless. A longer needle then is introduced through these wheals and then points *ABCXYZ* are connected by means of the subcutaneous injection of a 0.5 per cent. procain solution, thus completely encircling the operative field with an obtunded area.

For the blocking, Frazier draws a vertical line corresponding with the spinous processes. Parallel with this median line, two other vertical lines 2.9 cm. to either side are drawn, and, at a point corresponding with the space between the transverse processes, a transverse line is projected at right angles to the midline. The intersection of the transverse and lateral vertical lines marks the points at which the needle is introduced. After the location of the first intertransverse space has been identified by the successful injection of one nerve, as many more transverse lines as there are nerves to be injected are projected at a distance of 2.5 cm. above or below the first point of injection.

At these topographical landmarks, the needle is inserted, at an angle of 35 degrees to the skin-surface, to a depth of from 3 to 4 cm., into the thoracic and lumbar regions, respectively. When the needle comes in contact with the nerve, the patient experiences a sharp pain, which he refers to the terminal distribution of the nerve, but, which is soon allayed by the injection of a few drops of the solution. From 5 to 10 mils (cc.) of a 0.5 or 1 per cent. procain adrenalin solution is injected at each point, according to whether the injection is intra or endoneural or perineural. In the average case, where four laminæ are to be removed, some 80 mils (cc.) of the analgesic solution may be required.

Sawyer, in his studies on the cadaver, injected, with the needle, an alcoholic solution of methylene-blue directly into the nerve-root; but, on no occasion was a trace of the staining fluid found either within the dural sac or the cord, and he concluded that the possible danger of the analgesic solution reaching the cord directly or indirectly is a remote one.

Muraya also has made the relative toxicity of paravertebral and subcutaneous injections the subject of experimental investigations. Using a procain solution stained with methylene-blue, Muraya discovered the dye in the urine in from ten to 29 minutes after paravertebral injections. To safeguard the patient, Muraya advocates the use of adrenalin for delaying absorption of the anesthetic and a 5 per cent. gelatin-saline solution in order to delay diffusion.

SUPPLEMENTAL ANESTHESIA.

FRAZIER WARNS, THAT, as with regional methods elsewhere, owing to anatomical variations and other considerations, the intensity of the anesthesia may not be complete enough in all cases to permit conducting the operation throughout without pain. Under such circumstances, supplemental injections of procain solution must be made, especially in the removal of the spinous processes and laminæ, when the needle is introduced directly into the periosteum. Or, if need be, at this stage, nitrous oxid-oxygen anesthesia may be resorted to for a few moments.

After the spinal canal has been opened, subsequent manipulations may necessitate recourse to other methods of anesthesia according to the object to be attained. In the removal of tumors attached to the roots or in division of the posterior roots, Frazier has found the application of stovain on a pledget of cotton effective. Impressed with the fact that manipulation of the posterior roots played an important part in the production of shock, Frazier introduced the stovain (anesthain) block during laminectomies under general anesthesia, and he has found it equally as serviceable to supplement regional procain anesthesia. A thin pledget of cotton moistened with a 0.4 per cent. solution of stovain (anesthain) is brought in contact with the cord and roots at the level of the operation.

DIFFERENTIAL UTILITY OF REGIONAL ANESTHESIA.

REGIONAL ANESTHESIA is useful chiefly for operations in the thoracic region of the spine. While Braun has applied it in the cervical region, Frazier doubts the safety of the practice, because of the proximity of the phrenic center to the level of injection.

Infiltration anesthesia answers every requirement in the cervical segment, and is especially gratifying when tuberculosis is a complicating factor. Laminectomies in the lumbar region may be more readily performed under spinal anesthesia, as the procedure is less difficult and only one insertion of the needle and a single injection are required, instead of eight or ten for the regional method. Spinal anesthesia thoroughly obtunds the posterior roots—another valuable advantage. Operations on the spine, including injuries to the cervical cord, should be done under procain anesthesia, as the accompanying paralysis of the accessory muscles of respiration predisposes the patient to pulmonary congestion if etherization is used instead. By utilizing local and regional procain anesthesia, Frazier considers that the mortality of exploratory laminectomy, in itself, is no more dangerous than is an exploratory laparotomy.

SURGICAL POINTERS.

OTHER IMPORTANT points to be observed are: an ample exposure, implying the removal, in the first instance, of an adequate number of laminæ; x-ray identification of at least one lamina before beginning the operation, so that the opening corresponds precisely with the location of the lesion; coffer-damming with cotton the spaces on either side of the dural flaps, to prevent drops of blood from gaining access to the dural sac—a potential factor in postoperative adhesions; the gentlest manipulation of the cord or roots, and the *stovain* (*anesthain*) *block* as a prophylactic against shock; minute closure of the dural incision with fine needles and silk, to prevent the escape of cerebrospinal fluid; and careful juxtaposition of each layer-muscle, muscle-sheath, and intervertebral aponeurosis, together with superficial fascia—to ensure maintenance of function and the avoidance of disability after the removal of spines and laminæ. Observing these essential features, laminectomy may be resorted to with anticipation of the patient's recovery in all but exceptional instances.

WHOEVER HAS FOLLOWED the trend of events as regards the production of analgesia must have been impressed by the fact that on the Continent the tendency of surgeons has been to become emancipated from general anesthesia in their daily work, as much as possible, whereas the majority of American and English surgeons have faithfully worked for years to improve and safeguard general anesthesia. Dilating on this matter and giving his views on the technic of and results with regional anesthesia in extrapleural thoracoplasty and some intrathoracic operations, Willy Meyer of New York City, addressing the American Surgical Association, June 1, 1917, and publishing his remarks in the Annals of Surgery, October, 1917, said that:

Only a few surgeons here have employed regional anesthesia on a larger scale within the last years. That it must be an advantage to the patient not to have taken an anesthetic needs no discussion. Whenever the main nerve-trunks that feed the operative field can be reached with safety, regional anesthesia is feasible. All that is necessary on the part of the surgeon is practical experience and some patience as well as the time to wait until the fluid that produces the analgesia has taken effect.

It is important to remember that it is not a matter of necessity to have the needle strike the nerve-trunk itself, although this is naturally most effective and, usually, harmless, but that the *perineural infiltration* that is to say, the injection of the analgesic fluid into the tissues surrounding the nerve, suffices to block it. We know that sixty to seventy per cent. of all operations can nowadays be carried out under regional and local anesthesia. On my division at the German Hospital it has been practiced for many years.

The surgeon's principal reason for not using this splendid method more often is lack of time. One *has* to *wait* until the injected fluid has taken effect, and it takes ten to twenty minutes. It is absolutely necessary to wait this long in major operations in which the work involves a larger area. In the more localized operations, such as, for instance, thyroidectomy, or suprapubic cystotomy, a few minutes are sufficient to produce the desired effect. If the surgeon has to, or wants to, carry out the injection of the analgesic fluid himself, he will do well to first attend to the infiltration, after disinfection of that portion of the skin where the injection has to be made, and then get himself and the patient ready for the operation. *In our general hospitals it would seem to be in the interest of the work to have one man, e. g., one of the assistant adjuncts, become expert in regional anesthesia and then have him permanently assist in all these operations. He should "start the next case," just as we now are wont to have the anesthetist start the next general anesthesia.*

There certainly is no region of the body more favorable for the application of regional anesthesia than the thoracic portion and particularly the *chest-wall,* for there are the twelve pairs of thoracic nerves which feed it and can be reached with comparative ease and safety. But also some intrathoracic operations can be well done without general anesthesia. Only the virgin-pleura, when divided on opening the pleural cavity, usually answers with such tremendous reflexes that a few whiffs of an anesthetic become necessary at this time. Later on a drop of an anesthetic, administered now and then, suffices to enable the surgeon to do his work. An inflamed and thickened pleura stands handling very well under regional anesthesia.

An anesthetist certainly must be at the helm. Many patients are extremely nervous and irritable. Some will simply refuse the operation unless they *can be put to sleep*. In such cases we have conducted a sham inhalation anesthesia with a solution of one-half alcohol and one-half water, or exceptionally, have had a few drops of chloroform or anesthol administered, not enough to cause the patient to completely lose consciousness.

GENERAL CONSIDERATIONS OF THORACOPLASTY.

REGARDING MY OWN EXPERIENCE with regional anesthesia in thoracic surgery I have used it in cases of empyema and of lung abscess, in ligation of branches of the pulmonary artery, and particularly in extrapleural thoracoplasty. The latter term has been given to the operation of multiple rib resection, done in cases demanding compression of the affected side of the chest. The troubles that come into consideration in this respect are chronic suppurative inflammation of one or more lobes of the lung, of tuberculous or non-tuberculous character. As to the latter class, patients suffering from bronchiectasis have been subjected to the operation, mainly after branches of the pulmonary artery had been tied at a previous sitting for the purpose of producing shrinkage and calcification of the lung parenchyma by connective-tissue proliferation, after the lung had been thus deprived of its physiologic function (Sauerbruch-Gruns). In some instances I have also tried the effect of the operation without this preliminary procedure. In tuberculous patients the indication for extrapleural thoracoplasty has been established in the presence of cavity formation within the upper lobe, if compression by means of air- or nitrogen-insufflation into the pleural cavity had become impossible on account of adhesions that had formed between pulmonary and costal pleura, and hygienic medical régime had ceased to be of benefit.

As far as extrapleural thoracoplasty in bronchiectatics is concerned—to which class of patients my own experience with the operation so far has been confined—I hardly believe that it will be often resorted to nowadays. The evolution of the surgery of this chapter certainly points in this direction. Experience so far gathered has shown that, even with the preliminary ligation of the feeding branch of the pulmonary artery, the operation will but improve the disease—rarely cure it. Earlier cases of bronchiectasis in which all the lobes of one lung are affected seem to yield to methodical irrigation of the bronchial system of the affected lung with antiseptic fluids. When confined to one lobe alone pneumotomy with prolonged drainage will sometimes bring the desired result; a persistent bronchial fistula can be closed by a secondary operation later. In more advanced cases the excision of the affected lobe will have to be done in one or more stages. A number of surgeons, particularly in this country, are now hard at work trying to find ways and means of lessening the dangers of this operation. Hence, typical extrapleural thoracoplasty will at present come into consideration principally in cases of advanced pulmonary tuberculosis that are beyond help from the milder procedures and would be left to die if the bloody operation were not resorted to.

Figures 1, 2 and 3.

For the sake of completness I will mention that we have three methods of extrapleural thoracoplasty, that of Friedrich, Sauerbruch and Wilms.

Friedrich, at the suggestion of Brauer—both then holding positions at the University of Marburg—raised the scapula with the help of the typical Schede incision (Fig. 1), with the patient under a *very* superficial chloroform anesthesia. The tenth rib up to the second, or also including the first, were then resected subperiostally in their entire length. On account of its magnitude and frequent deleterious effect upon the heart's action in these weak and reduced patients, this method was soon abandoned. Sauerbruch then proposed the two-stage operation. He insists that it is of importance in weak patients with reduced power of expectoration, first to compress the lower lobe with the help of thoracoplasty, in order to avoid aspiration-pneumonia of this lobe from the cavity formation within the upper lobe. For this purpose he resects the fifth to the tenth, or the sixth to the tenth ribs inclusive, at the first stage. At the second stage, following in about two weeks, the upper four or five ribs with or without a portion of the clavicle are cut out. Only if the patient seems to have considerable power of resistance the greater part of the first to the tenth rib may be removed at once. He uses the so-called posterior hook incision, a cut that represents the posterior half of the Schede incision (Figs. 2 and 3). In all his operations he employs regional and local novocain anesthesia.

Wilms does not attach any particular importance to the primary compression of the lower lobe, but attacks at once the upper ribs. He also prefers to operate in stages and favors the so-called *columnar* resection, posteriorly as well as anteriorly, leaving the middle portion of the ribs in place (Fig. 4, *B*, *C*, *D*). In advanced cases of upper lobe cavity-formation the sternal portion of the clavicle is included in the resection in order to increase the compression (Fig. 4, *A*). Wilms also works with regional and local anesthesia.

It stands to reason that it must be of great advantage to these patients if the operation can be carried out under regional anesthesia. They thus remain able to expectorate at will, and have

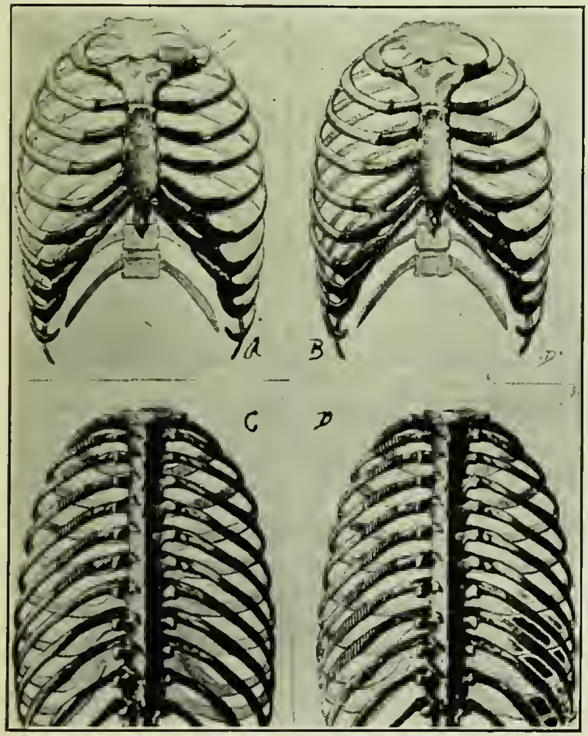

Figure 4.

their mouths free and unincumbered. The ever-threatening aspiration-pneumonia is thereby reduced to a minimum.

SENSORY INNERVATION OF THE THORACIC WALL.

THE SENSATION OF THE thoracic wall on either side is controlled by the twelve thoracic nerves. The first of these leave the intervertebral foramen between the first and second dorsal vertebræ, the twelfth between the twelfth dorsal and the first lumbar vertebræ. Immediately after they have made their exit from the spinal column, they divide into a stronger anterior and a weaker posterior branch (Fig. 5). Both are mixed nerves, *viz.;* they carry motor and sensory bundles. The anterior branch communicates with the sympathetic ganglion (Fig. 6), enters into anastomosis with its neighbors

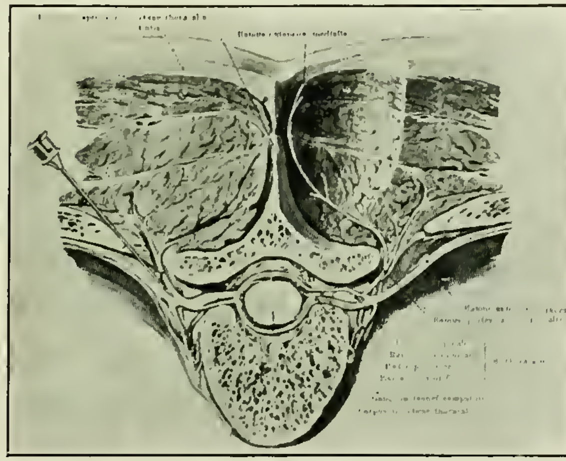

Figure 5.

Figure 6.

(ansæ or plexus), and innervates the broad muscles of the back. The posterior branch also anastomoses with its neighbors and innervates the long dorsal muscles and the skin of the back.

The anterior branches run in the intercostal space as *intercostal nerves.* Each of these gives off to the chest wall a nervus cutaneus lateralis, which subdivide again into anterior and posterior branches (*nervi cutanei laterales pectoris anteriores et posteriores*). Of the *upper* six thoracic nerves the anterior branches of these lateral nerves innervate the skin of the mammary gland and the gland itself; the posterior branches provide sensation to the skin of the back. Of the *inferior* six lateral cutaneous nerves the anterior branches run to the skin of the anterior adbominal wall, the posterior branches to the skin of the back (*nervi cutanei laterales abdominis anteriores et posteriores*). The intercostal nerves, after having given off the lateral cutaneous branches of the chest, feed the intercostal muscles. At the border of the sternum they perforate the major pectoral muscle and terminate as *nervi cutanei anteriores* in the skin of the anterior aspect of the breast.

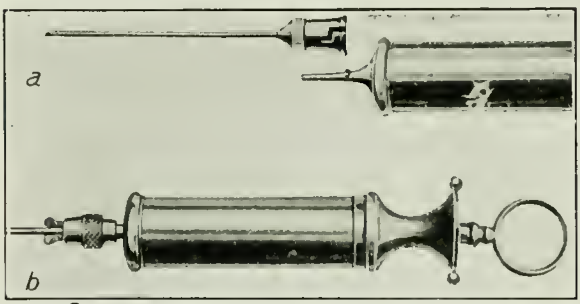

Figure 7.

INSTRUMENTS.

A SYRINGE TO WHICH the needle can be firmly attached by a bayonet-arrangement (Fig. 7, *a*), or by a special design (bit-clutch) (Fig. 7, *b*), is preferable to the well-known record syringe. The latter lacks the firm unison with the needle; besides, it works hard and affords no support to the surgeon's second and middle fingers during injection of the fluid. The needle must be fine and of sufficient length (6 inches).

SOLUTION.

A ONE-HALF PER CENT. solution of novocain with suprarenin is usually efficient. A strength exceeding one per cent. is inadvisable. One hundred to two hundred cubic centimeters (about 3 to 7 ounces) may be required. If sufficient time is allowed to elapse between injection and start of operation (about 15 to 20 minutes), the analgesia will in most instances be satisfactory. If the patient reacts, a very few drops of an anesthetic will quiet him. The hypodermic injection of morphin, or pantopon (one-half grain), one hour before the beginning of the operation, is of great assistance.

Whether the additional hypodermic administration of scopolamin is advisable I am not prepared to state as yet. We have seen most satisfactory results from this combination in all kinds of major operations. Perhaps it will prove equally beneficial in thoracic cases. The reason that I have not tried it has been that I feared it might not leave the patient sufficient self-control to cough and expectorate. If it were determined that this fear was unfounded, a hypodermic of scopolamin might be added with advantage also in these cases.

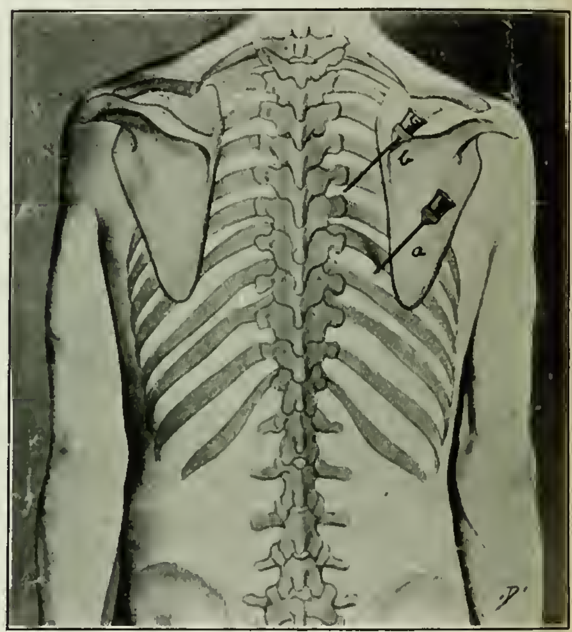

Figure 8.

TECHNIC.

THERE ARE TWO good methods at our disposal. One was worked out at the

Zurich Clinic (Sauerbruch), and published by the late Schumacher; the other is practiced at the Kiel Clinic (Anschuetz), and was published by Kappis. Both appeared in print at the same time (Centralbl. f. Chir., 1912, No. 8, pp. 249 and 252).

In the first method the nerve is reached at the angle of the rib (Fig. 8, *a*), in the second it is reached proximally to this location, *viz.:* anteriorly and inwardly from the angle (Fig. 8, *b*). Here the thoracic nerve with all its branches can be infiltrated. The technic of the Kiel procedure is more difficult. In carrying it out the needle must strike the rib at or near its articulation with the transverse process of the vertebra. The location of this articulation is usually found 3½ cm. (1⅜ inches) to the left or right of the median line. The difficulty is, that(because of the rib running forward and inward at this place, one cannot palpate its proximal extremity through the bellies of the thick muscles near the spine. However, even in stout individuals one of the lower ribs usually can be made out somewhere in the back. If the lower border of this rib is projected in the direction of the same medially, the point of entrance for the needle is found at the spot where this projection line crosses a perpendicular line drawn parallel to and 3½ cm. to one side of the median line, *viz.:* the spinous processes (Fig. 9). The next lower border of a rib above or below is about 3 cm. (1³⁄₁₆ inches) distant. In order to facilitate the work of finding the respective point of entrance at the subsequent ribs I had a flexible (sterilizable) tape-like metal-strip made, with a 3 cm. scale on one side and a 2½ cm. scale on the other (Fig. 9, *A*). This has been found a useful addition to our instrumentarium.

Figure 9.

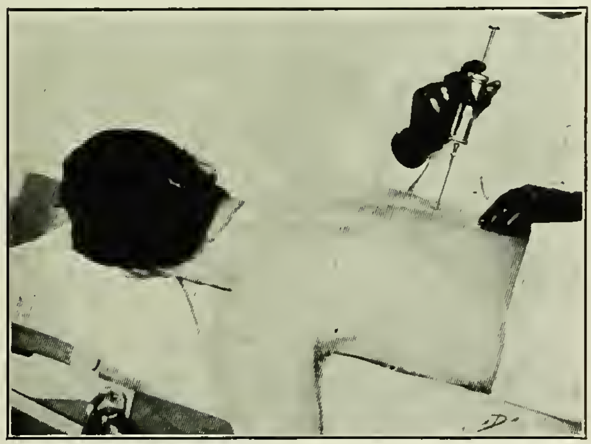

Figure 10.

After the respective number of the palpable lower rib in the back has been ascertained all one has to do is to count the markings on the scale upward and find the top rib that is wanted. From here the operator will then proceed downward with the infiltration from rib to rib, as many as have been slated for resection. Or, if the lower rib, the number of which has been made out, lies within the operating field, one can commence infiltrating the thoracic nerve of this rib and then advance upward, step by step, at 2½ to 3 cm. distance. It seems best to commence with the lower rib and work from below upward.

Of course, this distance of 3 or 2½ cm. is not found correct in every instance. It varies with the size of the patient. Still, as an average, the marked distances have been a welcome aid. In order to be on the safe side, the thoracic nerve of the two ribs beyond the field of thoracoplasty, above as well as below, are included in the blocking.

For both methods the patient lies on the operating table, best on his stomach, with his head close to the upper end, and both arms hanging down perpendicularly (Fig. 10). A sand-bag or other round pillow supports the adbomen to overcome the lordosis. After proper disinfection and iodinization of the entire back, regional anesthesia is started.

If the Zurich procedure is chosen, the line of the paravertebral skin incision (Fig. 2) is anesthetized first and *within this* line the needle is painlessly introduced. The latter is advanced from below and inward in an upward and outward direction toward the angle of the rib above. When the grating sensation is felt one to two cc. of the fluid are deposited. The needle tip then finds the lower border of the rib, where 5 to 8 cc. are injected. About 10 cc. of all are used. The same procedure is then repeated with each successive rib.

If the Kiel method is used one of the lower ribs is carefully palpated and now the first point of entrance located as just described. The point of puncture is first frozen with the ethyl chlorid spray. The operator's nail marks the place for freezing the skin. As soon as the spot has turned white the needle is pushed through the skin and conducted slowly down in a straight sagittal line until it touches the bone. In the average case the distance from the skin to the rib measures about 4 to 5 cm. (1½ to 2 inches). The scratch of the needle's tip on the bone must be clearly felt. Now the operator searches with the needle the lower border of the bone and then pushes it gently forward in a slightly inward direction toward the spine for about 1½ cm. (¾-inch) (Figs. 5, 9 and 10). At various depths the fluid, 8 to 10 cc. in all, is injected. In this process the nerves most likely often are hit and their substance directly imbibes the novocain solution. But this leaves no deleterious effect. Step by step, with the same technic and continued care, the respective ribs are treated. One must remember that when attending to the upper ribs, the increasing thickness of overlying soft tissues makes the needle sometimes pass to a depth of nearly 5 to 6 cm. (2½ inches), before it strikes the bone. When the last rib above—according to previous determination—has been attended to, it is necessary to wait for 15 to 20 minutes before starting to make the incision—*the* important point which I would like to particularly emphasize once more. The mistake we all are prone to make—thereby depriving ourselves and the patient from reaping the full benefit of the regional anesthesia—is, that, owing to lack of time, we cut down these minutes.

Complications, such as puncturing blood vessels or the lung, have not been observed. Neither method appears to be connected with danger to the patient. Kappis has seen that when the needle pricked the pleura, the patient suddenly began to cough. He withdrew the needle somewhat, giving it a different direction, and no harm resulted.

The strength of the solution should be ½ per cent. This was used at Zurich with satisfactory results. Kappis employed a 1 to 1½ per cent. solution but states that he intends to reduce the strength. In one of my cases a most profound collapse occured after liberal use of a one per cent. novocain solution, about 80 to 100 cc. The operation, (thoracoplasty on a bronchiectatic) had to be postponed. Six days later the 1½ per cent. solution, applied in the same manner, gave a satisfactory result.

I have so far practiced Kappis's method only; this for the reason that it appealed to me as anatomically particularly efficient. However, I shall not fail to try Schumacher's method as soon as an opportunity presents itself. The analgesia derived from the latter has been lauded by many colleagues who had a chance of seeing it carried out. The amount deposited at each rib is about 10 cc. in both methods, as stated above.

RESULTS.

MY CASES OF extrapleural thoracoplasty done under regional anesthesia, seven in number, were all bronchiectatics. The operations were done at a time when I tried the effect of this procedure in advanced, non-tuberculous suppurative affections of the lung; in three of them branches of the pulmonary artery had been ligated at the first stage. I have been much pleased with the working of the anesthesia; now and then a few whiffs of an anesthetic were required, especially in reduced nervous individuals.

In one case, a thoracoplasty requiring resection of the first to the tenth rib, an ideal regional anesthesia—without the addition of any inhalation—was obtained, the patient conversing during the entire operation, never once complaining of pain.

Extrapleural thoracoplasty for advanced pulmonary tuberculosis—the real field for this operation—I have not been able to carry out so far, owing to the impossibility of getting such patients admitted to the hospitals with which I am connected. All my efforts in this direction within the last five years were thwarted. However, I am glad to be able to add, that it is now planned to have two rooms in the Thoracic Pavilion set aside for this class of patients.

The fact that more than 66 per cent. of these otherwise entirely hopeless cases have been greatly improved or cured at the hands of surgeons abroad by such compression from without, with the help of thoracoplasty, should serve us as a stimulus to find ways and means by which it may become possible to afford patients of this type the opportunity of benefiting by operative procedure, thus saving at least a number of them from certain death.

Regional anesthesia has been successfully applied by me so far in only one patient with advanced pulmonary tuberculosis with cavity formation in the left upper lobe, on whom I performed Tuffier's operation. Here, after resection of a piece of the third rib in the anterior axillary line and division of the posterior lamella of the rib periosteum plus endothoracic fascia, the costal pleura was gently pushed off the chest wall, including the apex of the lung, and then a paraffin-plumb introduced.

The same method of regional anesthesia has been many times carried out in single or multiple rib resection for empyema, in pneumotomy for lung abscess, exploratory thoracotomy for lung tumor and for ligation of a branch of the pulmonary artery. In one of the latter cases the patient, an intelligent young man, was conscious during the entire operation. Only at the time of opening his pleural cavity, which showed no signs of chronic inflammation, a small amount of an anesthetic had to be administered.

There can be no doubt that regional anesthesia represents a great asset in the successful performance of extrapleural thoracoplasty as well as in some intrathoracic operations.

LOCAL AND COMBINED ANESTHESIA IN CESAREAN SECTION . SENSITIVENESS OF THE ABDOMEN AND ITS CONTENTS . THE ANESTHETIC AND OPERATIVE TECHNIC . CLOSING-UP THE INCISIONS . EFFECTS OF LOCAL AND COMBINED ANESTHESIA . VAGINAL AND VAGINO-PELVIC OPERATIONS UNDER LOCAL ANESTHESIA . PRELIMINARY COMFORTS . ROUTINE OPERATIVE PROCEDURES . PERINEUM . ANTERIOR VAGINAL WALL . HYSTERECTOMY . CONCLUSIONS . PARAVERTEBRAL ANESTHESIA . TYPES OF OPERATIONS AND COMPLICATIONS . EFFECTS OF ANESTHESIA . NECESSITY OF ADDITIONAL ETHER . REPORT ON PARAVERTEBRAL ANESTHESIA . PREPARATION FOR ANESTHESIA . RESULTS OF OPERATIONS . LIST OF OPERATIONS . MORTALITY IN MANY AND VARIOUS OPERATIVE PROCEDURES.

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SPECIALISTS ARE MORE and more coming to the realization that anesthesia offers a wide field of selection for certain operative procedures, types of patients and varieties of pathological conditions. Recently such authorities as William Mortimer Brown of Rochester, N. Y., J. Clarence Webster of Chicago, and H. H. Trout of Roanoke, Va., have been emphasizing the peculiar utility of local and combined anesthesia for cesarean section. Speaking before the Thirty-first Annual Meeting of the American Association of Obstetricians and Gynecologists, Brown, as reported in the American Journal of Obsterícts, Vol. lxxviii, No. 6, 1918, said:

"At times, there arises in a given case a combination of complications that leaves us but small choice of procedure in order to achieve a successful result. That we have been slow to recognize this situation, is borne into my mind when I recall how, only a few years ago, I watched one of our foremost teachers in obstetrics do a cesarean section in the case of a woman with a contracted pelvis, and then, a few days later, saw him put a patient, who had a dilated heart, on the same table and attempt a manual dilatation under a general anesthetic. The woman died, undelivered, after twenty minutes manipulation. We are in a position now to say that, in certain types of cases, abdominal delivery, under use of a *local anesthetic,* offers the safest means of terminating pregnancy and that this method is entitled to a definite and permanent place in our records of progress."

Brown considers that, in a general way, the patients in whom this procedure is indicated are those in whom, by reason of some intercurrent disease, a general anesthetic is contraindicated and for whom a difficult labor is unsafe. Such cases are:

1. Patients with advanced cardiac disease, in whom there is actual or impending muscular re-

laxation. These cases, if there is actual or fair compensation, will often go, under careful hygiene, to the final weeks of pregnancy; but, these subjects are in no condition to undergo even the shortest labor, nor is the relaxation of a general anesthetic safe. The child is viable and active; the mother, if relieved of the strain of her pregnancy, has a prospect of fair health for some time. Such patients are entitled to abdominal delivery under local anesthesia.

2. Patients suffering from severe toxemia, hepatic, renal insufficiency, and impending eclampsia. For some time, abdominal hysterotomy has been growing in favor among many obstetricians, and Brown, with no intention of discussing the merits or demerits of this operation for the relief of profound toxemia, considers that there come to hand occasional cases in which this form of delivery is positively indicated, and that, for the same reasons, local instead of general anesthesia should be preferred.

3. A third complication that may render abdominal delivery under local anesthesia desirable is, according to Brown, pulmonary tuberculosis.

J. Clarence Webster of Chicago (Amer. Jour. Surg.: Anest. Sup., October, 1918) and H. H. Trout of Roanoke, Virgina (Surg. Gynecol. & Obstetr., July, 1918), also have paid especial attention to the development of local and combined anesthesia for cesarean section. During nineteen years of clinical service in the Presbyterian Hospital, Webster has given special attention to the use of anesthetics in pelvic and abdominal surgery and obstetrics. He always deplored the indiscriminate use of ether and was among the first to use Schleich's infiltration method for minor and major surgery in the aged, and in renal, pulmonary, and cardiac diseases, marked anemia, and chronic wasting diseases and sepsis. Since then, he has abandoned Schleich's solution in favor of procain and, since 1909, has performed all his cesarean sections under local anesthesia, whenever general anesthesia seemed contraindicated; and more recently has done many cesarean sections under combined procain local anesthesia and nitrous oxid and oxygen narcosis. In 1913, Webster advocated the use of methylene-blue, to color the infiltrating solution and to delimit, for the operator's guidance, the extent of the area infiltrated. In this way, the operator need not insert knife, scissors or needles into unobtunded tissues.

SENSITIVENESS OF THE ABDOMEN AND ITS CONTENTS.

WEBSTER, TROUT AND BROWN have verified the researches of the late Lennander of Upsala, regarding the sensitiveness of the abdomen and its contents. Curious to note, Lennander does not mention the sensibility of the uterus, either in the pregnant or the nonpregnant condition, further than to say:

"All organs receiving their nerve supply only from the sympathetic nerve and from the vagus, below the branching off of the recurrent nerve, have no sensation. According to my observation, therefore, the abdominal and pelvic viscera are devoid of nerves to convey the sense of pain, pressure, heat or cold."

Webster has found the abdominal wall sensitive in its entire extent. Also the parietal peritoneum is everywhere particularly sensitive, whether it be pulled, sutured, cut or pinched. Separation of adhesions between any structure and the parietes causes pain, unless the adhesions are very slight. The visceral peritoneum is, in general, insensitive. Separation of adhesions between viscera or between them and new growth causes no pain, unless traction is made upon ligaments or mesenteries. Ligation, division or cauterization of the omentum is not noticed by the patient. If it is forcibly pulled down, distress is caused. Similarly, the intestines are insensitive, but, if they are handled so that their mesenteries are stretched, pain is caused. Removal of the vermiform appendix causes no distress, except when adhesions between it and the parietes are separated or its mesentery is stretched. Compression, ligation or division of the broad ligament causes pain.

Incision, suturing or cauterization of the uterus as a rule is not noticed, however, the patient complains of nausea and distress when too much traction is exerted and the ligaments of the uterus are stretched. This assertion is supported by the fact that Trout found, in his eighteen cases under purely local anesthesia, that the most painful part of the performance of cesarean section was the lifting of the urterus out of the abdominal cavity.

Webster has further observed that, when the adnexa are adherent to the pelvic wall, separation causes distress, while gentle manipulation ordinarily is unnoticed. When an ovary is squeezed, cut or sutured, distress it felt. Separation of the bladder from the uterus produces little or no discomfort; but, division of the wall of the vagina in a hysterectomy causes pain. Sponging of the visceral peritoneum is painless, whereas the same procedure, applied to the parietal, causes distress and pain, varying with the degree of force employed. The pain caused by the removal of a gauze pack from the abdomen results, probably, either from irritation of the parietal peritoneum or from traction upon some part of the mesentery. Slow injection of hot physiologic salt solution (105° to 108° F.) is not distressful, unless the abdomen is unduly distended.

Pain felt within the abdominal cavity, whether in disease or during operation, has to do with the parts innervated by the intercostal lumbar, and sacral nerves.

THE ANESTHETIC AND OPERATIVE TECHNIC.

TROUT PRECEDES OPERATION with a hypodermic injection of morphin (⅛ grain) and uses a 0.5 or 1 per cent. solution of procain, preferably without adrenalin. Trout has injected up to 250 mils (cc.) of this solution without resulting untoward effects. The skin is infiltrated in the usual manner, by forming one wheal after another. Webster obviates the initial distress of the needle-prick by first producing nitrous oxid and oxygen analgesia. He advises this combination also because it generally is advisable to make a large incision in the abdominal wall, in order to expose the separated recti-abdominis muscles, for the purpose of making a satisfactory closure of the wall at the end of the operation. Trout considers the preferable incision one, the middle of which is at the umbilicus and the upper end at the level of the fundus of the pregnant uterus.

The fascia is infiltrated in exactly the same manner as the skin. The muscles generally are thin and their fibers part without trouble. A small opening then is made in the peritoneum and the index finger of the left hand inserted, and the peritoneum is infiltrated, keeping the finger on the inside as a guide for the needle, while injecting this very thin membrane. This part of the procedure is easier than is commonly supposed; however, Webster insists that the thorough infiltration of the parietal peritoneum at the site of incision must be accomplished.

A self-retaining retractor is then placed in the abdominal incision, which is stretched as widely as may be necessary. In this way, the anterior wall of the uterus is exposed. If the patient is nervous and strains at all, so as to force omentum or intestines down from above, Webster advises the introduction of a long strip of gauze, soaked in warm salt solution, between the abdominal wall and the upper part of the uterus, after the latter has been carefully lifted out of the abdominal cavity. It is important, as Trout suggests, to have the upper part of the abdominal incision so placed as to be slightly higher than the fundus of the pregnant uterus, as in this way that organ can be allowed to ride out of the peritoneal cavity, thus obviating the only distressing part of the operation. If the incision is not made too long, the abdominal wall will hug the uterus and serve to retain the omentum and intestines without the need of using a gauze pack or sponges.

Next, Webster advocates the injection of two ampulesful of pituitrin into the wall of the uterus. When blanching and hardening of the wall begins to be well established, a vertical incision of about 5 inches in length is made into the upper part of the anterior uterine wall, as near the midline as possible. It is not necessary to infiltrate the uterine wall with the procain solution, since incision of the body of the uterus causes no pain.

The incision is carried down to the amnion, which immediately bulges through the opening. At this stage of the operation, Brown fastens the uterine wound-edge to the abdominal incision with four or five ordinary towel-clamps, not only in order to fix the uterus in position, but, also, to prevent the blood and amniotic fluid from entering the peritoneal cavity. In addition, an assistant may be instructed to press the abdominal wall against the uterus and to maintain a steady pressure during the emptying of the organ.

As a matter of precaution and to save time, after incision of the uterus, Trout places a line of interlocking sutures of chromic catgut on each side of the fundus of the uterus. These lines are about an inch apart and placed in the long axis of the uterus, thus controlling all bleeding. These sutures go through the whole muscular wall, and the assistant on either side makes traction upon each side on the entire line, thus lifting the uterus up, steadying it, and controlling hemorrhage. The use of pituitrin obviates the necessity for making these interlocking sutures.

Now the amion is opened, a hand is introduced to grasp the breech of the fetus, and the latter is extracted and given to an assistant, after division of the cord. The extraction of the fetus sometimes causes the mother distress, when undue force has to be exercised in turning or delivering. In such instances, the concomitant resort to nitrous oxid and oxygen anesthesia gives relief. The uterus now rapidly retracts and frequently the placenta is partly expelled through the incision ; the hand is reintroduced to peel it and the membranes from the greatly reduced area of the uterine wall.

If the cervix be undilated, as many times occurs in primiparas, it may be opened by means of dilators passed through the uterine incision, thereby providing drainage from the uterus.

CLOSING UP THE INCISIONS.

THE INTESTINES SHOULD now be carefully covered with saline packs and the uterine incision closed. Trout approximates the incision by tying the interlocking sutures across the line of the incision, supplemented by a continuous suture of plain catgut, approximating the peritoneal surfaces, so as to leave no spots for future adhesions. Webster apposes the broad surfaces of the incision by means of several layers of continuous iodized catgut. Through and through strong, braided-silk sutures, made noncapillary by rubber infiltration, are passed through the skin, anterior sheath-layers and recti muscles. The anterior sheath-layers are approximated with iodized catgut, the skin edges brought together with fine silk or linen, and the large silk splint-suture tied last.

As a rule, Webster has found that the initial procain infiltration of the abdominal wall endures long enough to permit the suturing of the incision, without causing pain or further need of obtunding. If there is anxiety or any slight distress at this stage of the operation, Webster induces nitrous oxid and oxygen analgesia, so as to quiet the patient.

EFFECTS OF LOCAL AND COMBINED ANESTHESIA.

IN THE MAJORITY of cases, babies, delivered by cesarean section under local or combined anesthesia, breathe very soon after extraction, except when the mother is eclamptic, toxemic or septic, or when there is some obstetrical or organic complication embarrassing the initiation of respiration. Premature babies or those with defective hearts may be stillborn. There always is the possibility of resuscitation by artificial respiration by means of the various methods, or oxygen perflation should be tried.

There can be no doubt, concludes Webster, that, as regards the *fetus in the uterus,* cesarean section under local anesthesia causes the least disturbance and that nitrous oxid and oxygen analgesia in combination with local anesthesia, detracts little from its safety and may add considerably to the comfort of the mother. After delivery and before tying the cord, it is quite possible to oxygenate the child through the maternal circulation, reestablishing the analgesia after the cord has ceased pulsating.

IN CONSIDERATION OF the facility with which local anesthesia may be applied in the surgery of the vagina and adjacent structures with satisfaction to the surgeon and safety and solace to the patient Robert Emmett Farr of Minneapolis, Minn., cannot avoid the conviction that the failure on the part of surgeons, generally to use local rather than general anesthesia in this work must be due, more or less, to a lack of familiarity with the application of novocain and with the satisfaction resulting from its use. With this in mind it has occurred to Farr, that to recount, with careful detail, the technic which, in his hands, has been so satisfactory, might serve to stimulate the more frequent use of this method and, incidentally, might render some aid to those not so familiar with this kind of work. The nerve supply of this region is easily reached and blocked, infiltration is simple, and the anesthesia so safe and easy to attain that it would seem that general anesthesia should be used only occasionally in this work, rather than the reverse which is now true.

PRELIMINARY COMFORTS.

IN ALL OF THIS WORK the avoidance of pain is essential. Any move which will cause pain must be anticipated, and the surgeon must remain absolutely in the safe zone. I once saw a well known surgeon precede the operation of perineorrhaphy, under so-called local anesthesia, by pinning to the perineal body a sterile towel before any anesthetic had been given. Small wonder that this poor woman begged for mercy, and condemned the method. Furthermore, the individual who could bring himself to the performance of such an act is not properly constituted for the administration of local anesthesia. One must almost be able to feel the pain himself, so keen must be his sympathy. In no case is it to be an ordeal or a test of how much pain the patient can stand.

In this class of work much may be done to overcome the disagreeable features which usually precede and follow an operation. A good rest is assured by giving the patient a liberal dose of some hypnotic the night before operation. Upon awakening, she is given $\frac{1}{200}$ grain scopolamin and $\frac{1}{3}$ grain of pantopon. She should not see visitors, or be *fussed with* by the nurse before operation. If the patient is very apprehensive, this dose is repeated one-half hour before operation. This would seem to be a safe dose, and it is given only for its psychic effect. We consider it no more necessary here than in conjunction with general anesthesia, where it is likewise a great source of comfort. In elderly women one-half the dose mentioned is given with about the same effect. The ideal anesthesia is complete narco-local, with the patient in a light twilight sleep, with the addition of novocain.[1] There

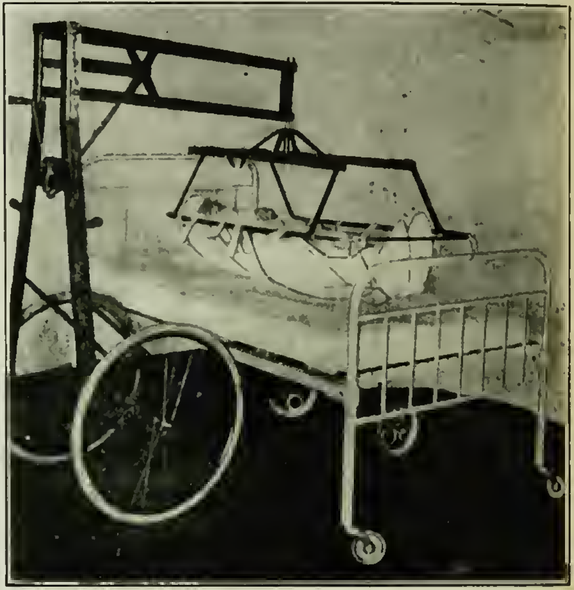

Fig. 1.—Invalid lifter, designed for the careful handling of operative patients.

1. Farr, Robert E.: Narco-Local Anesthesia, St. Paul Med. Jour., May, 1916. Narco-Local Anesthesia in Surgical Works, Journal-Lancet, September 1, 1916.

seems to be some doubt as to the safety of scopolamin in such large dosage, however, and the writer has not adopted this procedure, though from the viewpoint of comfort to the patient it is well nigh ideal. In moderate doses there seem to be almost no unpleasant effects.

The comfort of the patient is further enhanced by careful handling during the trip to and from the operating room, for which purpose I have devised an invalid lifter (Fig. 1). The knee-holder (Fig. 2) aids greatly in securing a comfortable position on the table, which is essential; the limbs are brought into position and the knee-holder adjusted to them. Another essential is the presence of a skilled anesthetist whose duties are to furnish the patient with water, advice, and every comfort possible; who records the blood pressure, controls the pneumatic injector, and keeps a written record of the several steps of the operation. Music is not objectionable and makes the time seem to pass more quickly.

ROUTINE OPERATIVE PROCEDURE.

THE OPERATIONS most frequently presenting are curettage, amputation of the cervix, anterior colporrhaphy, perineorrhaphy, removal of labial cysts, the treatment of infections of the glands of Bartholin, urethral caruncle, the closure of fistulae, and vaginal hysterectomy. With the exception of vaginal hysterectomy, which, under certain conditions, does not readily adapt itself to this form of anesthesia, every one of these operations may be done under local anesthesia with satisfaction. Operations on the labia and on the urethral orifice, or on the skin of the perineum may all be done under direct or circumferential (Hackenbruch) infiltration, and present nothing different from the removal of growths from the skin on any other part of the body. The points which remain for consideration are: (1) The repair of the perineum; (2) plastics on the anterior vaginal wall; and (3) operations on the cervix and uterus.

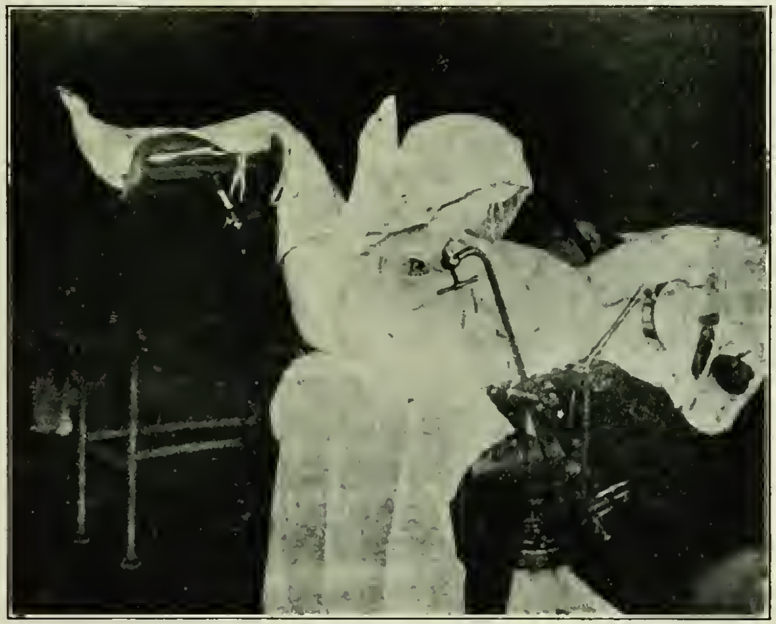

Fig. 2.—Adjustable knee-holder, designed to give the maximum comfort to patient.

1. *Perineum.*—Anesthesia for operations on the perineum may be accomplished by either of two methods or by a combination of these. A direct infiltration may be made of all tissues which are to be subjected to trauma, or the nerve supply may be blocked at some distance from the vagina. We have found most satisfaction from a combination of these methods. In other articles in the Year-Book I have called attention to the necessity of always remaining outside the sensitive area in introducing the anesthetic. Naturally there will be produced a slight amount of pain with the first needle prick. This should be the only real pain experienced by the patient throughout the operation. From this first point the point of future needle stabs may be anesthetized from beneath. It is my practice to make the first dermal wheal just within the skin-margin at the midpoint of the posterior vaginal wall (Fig. 3). From this point the needle may be slipped along beneath the skin forward to a point opposite the clitoris, a liberal amount of the solution being allowed to escape as the needle is withdrawn (Fig. 4-A). This process is repeated on the opposite side and through the same stab-wound a second wheal is made from beneath, two inches to the right and left to the central point. From here the needle is introduced toward the tuberosity of the ischium until the deep pelvic fascia is pierced (Fig. 4-B). This procedure will be noticed by the patient but will not be complained of. This fascia is sufficiently dense for the surgeon to appreciate the passage of the needle through it. A liberal amount of novocain is deposited here over an area approximately the size of a walnut, moving the needle back and forth and changing its direction slightly at each stroke. The pudic nerve will be reached by the solution in this way. This procedure is repeated on the opposite side, and, in addition, a line of infiltration is established across the perineum (Fig. 4-C). One may now delay for a few minutes, when anesthesia will be complete and the perineal repair may proceed under perfect anesthesia; or, one may introduce the needle in the midline and, by forcing in a liberal amount of novocain, prac-

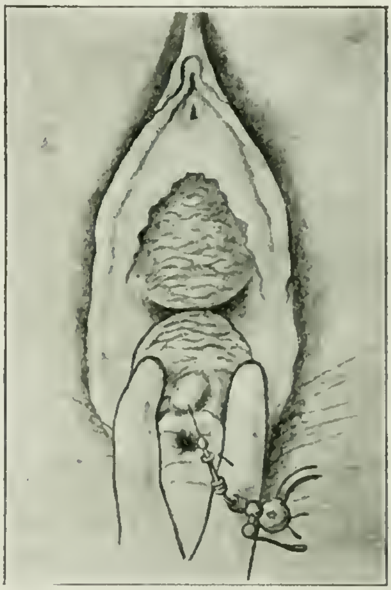

Fig. 3.—Point of making initial wheal in perineum.

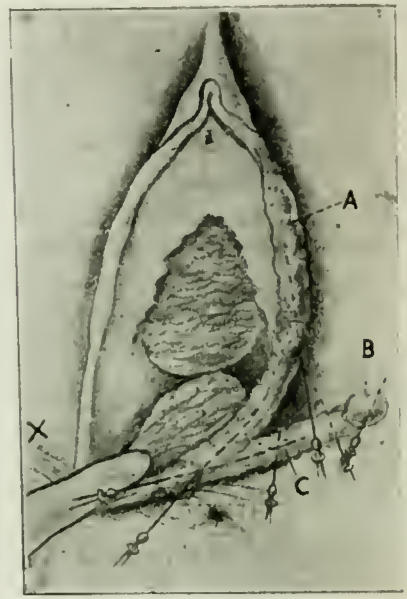

Fig. 4.—A, labial infiltration; B, pudic nerve blocking; C, line of perineal infiltration.

tically dissect up the vaginal mucous membrane by means of the solution (Fig. 5). This takes but a few seconds and the operation may proceed at once. The whole procedure should be carried out with great deliberation, but, if done methodically, after a little experience it can be accomplished in not more than five minutes. The separation of the layers of the septum with blunt-pointed, curved scissors is facilitated by the *blowing up* process. Most of the fluid which has been injected between the vagina and rectum will flow out as the dissection proceeds and will in no way obscure the structure of the tissues with which we are dealing. Furthermore, the action of the adrenalin will so control the hemorrhage, and the structures will be so quiet on account of the absence of the transmission of respiratory movement, that the operation may be performed with greater ease than under general anesthesia, where the hemorrhage tends to obscure the tissues and the to and fro motion of the vaginal and rectal walls, which occurs in many patients under general anesthesia, tends to cause more or less embarrassment. Any type of operation one chooses may be used for the repair.

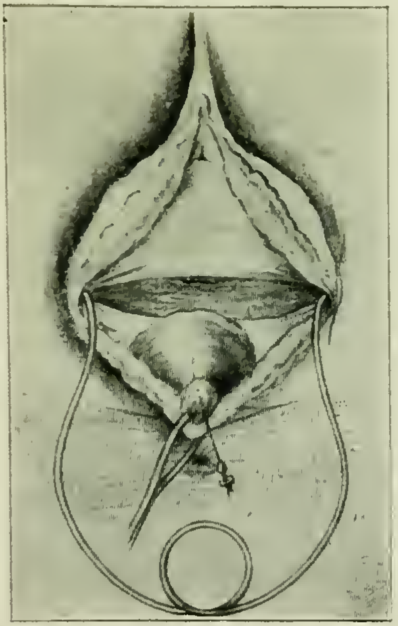

Fig. 5.—Infiltration or "blowing up" process of recto-vaginal septum.

2. *Anterior Vaginal Wall.*—The anterior vaginal wall will be blocked to some extent by the above technic; however, the dissection is facilitated and the anesthesia is made so much more sure by the process of infiltration that we use it in the entire wall as a matter of choice (Fig. 6).

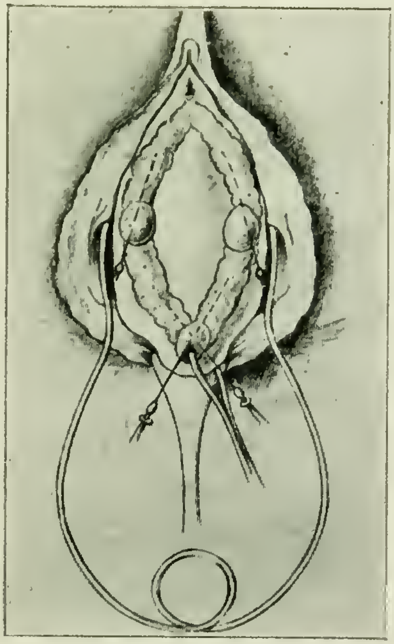

Fig. 6.—Circumferential infiltration of anterior vaginal wall.

The area to be excised or operated on may be circumscribed, or infiltrated directly (Fig. 7-A). The same general rules should be followed here as elsewhere. All infiltrations should be made from the point first punctured, or from points subsequently anesthetized from beneath. In every case in which the introduction of the speculum, or traction on the same, produces any degree of discomfort to the patient, the first step of the procedure described above should be carried out (Fig. 4-A).

3. *Cervix and Uterus.*—Ordinarily the cervix may be grasped without producing pain; however many patients do complain of pain when this procedure is attempted. It has, therefore,

been my practice to produce a wheal before the cervix is grasped by the tenaculum (Fig. 7-B). The technic for rendering the cervix and uterine mucous anesthetic is as follows: With a four-inch needle (Fig. 8) a wheal is made to the right or left of the cervix. The needle is then advanced from 1.5 to 2 inches parallel to the mid-line of the uterus, traction being made on the cervix the while. As the needle is withdrawn the fluid is allowed to escape into the parametrium. The direction of the needle is changed with each stroke, and an effort made to inject the tissues to the side of the uterus, one-half to three-fourths of an ounce of novocain being used. This procedure is repeated on the opposite side, when dilatation of the cervix may be begun. In from five to ten minutes painless currettage may be accomplished. For amputation of the cervix a ring is infiltrated around the cervix in the vaginal vault, this infiltration being allowed to extend well into the tissues of the cervix throughout the entire circumference (Fig. 7-B and Fig. 9).

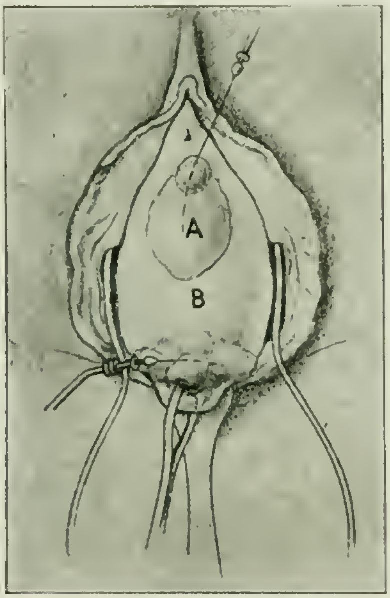

Fig. 7.—A, infiltration or "blowing up" process of vesicovaginal septum; B, infiltration of anterior vaginal fornix.

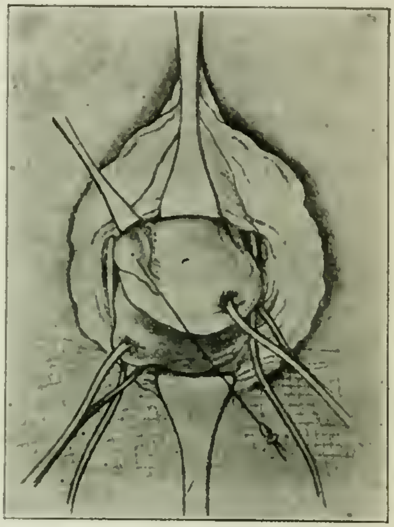

Fig. 8.—Schematic. Infiltration of right parametrium with novocain.

Hysterectomy.—My experience in the performance of vaginal hysterectomy is limited, as I much prefer the abdominal route for this work; however, we occasionally see elderly patients with uterine prolapse and ulceration of the cervix and the vaginal wall which condition, in the absence of malignancy, is best handled by a vaginal operation. When necessary, this operation is preceded by a preliminary injection about the introitus (Fig. 4), as in the operations previously described. The area in the vaginal vault to be incised is outlined by a line of infiltration (Figs. 7-B and 9), the cervix is grasped with a tenaculum, and the procedure for blocking the broad ligaments is carried out (Fig. 8). Anterior and posterior infiltration is made sufficiently deep to anesthetize the peritoneum. The uterus is removed as under general anesthesia, care being exercised to make a secondary blocking of the round ligaments as soon as they present in the field (Fig. 10). Traction upon the round ligaments causes distress, but not great pain, and this should be anticipated by blocking as far away from the uterus as possible. They may later be united with the broad ligaments in the vaginal vault without difficulty. For the performance of the Watkins-Wertheim operation the vaginal wall is prepared as in Fig. 6, and a broad, deep infiltration made in the anterior vaginal vault. The uterus may be turned out and the round ligaments blocked after they are exposed and before traction is made.

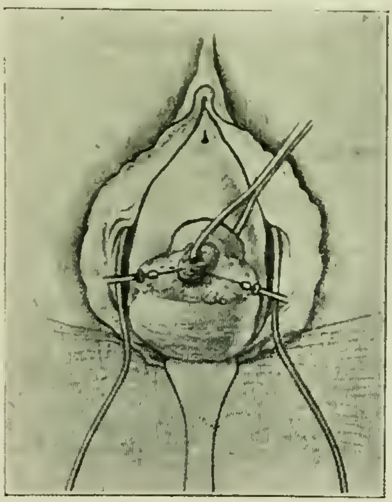

Fig. 9.—Infiltration of posterior vaginal fornix.

A great deal of vaginal work must be performed in conjunction with abdominal work and here the method has considerable advantage. The delay necessary in making preparation for the second operation always necessitates prolonging general anesthesia and time becomes a more or less important factor. Where novocain is used, the element of time is a relatively unimportant factor; the element of labor, however, must be considered as the introduction of novocain solution with the ordinary syringe is quite irksome. For this work I make use of the pneumatic injector in all cases. It eliminates practically all of the disadvantages of the syringe and is often the deciding factor in the choice between general and local anesthesia.

CONCLUSIONS.

1. A large percentage of vaginal and vagino-pelvic work may be accomplished under local anesthesia more safely and with greater comfort to the patient than with the use of general anesthesia.

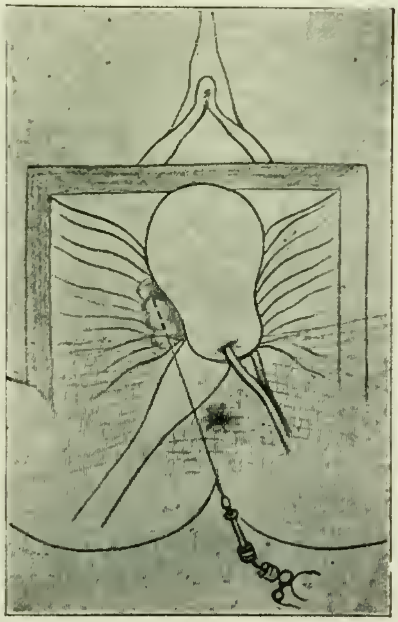

Fig. 10.—Vaginal hysterectomy. Fundus has been delivered through anterior fornix. Novocain infiltration of right round ligament.

2. With a standardized technic and proper equipment the demand for general anesthesia in these cases should decrease more rapidly in the future than it has in the past, and local anesthesia should come into its own.

SPEAKING BEFORE THE Section on Obstetrics, Gynecology and Abdominal Surgery of the American Medical Association, 1918, Nathaniel R. Mason and Frank C. W. Konrad of Boston, Mass., point to the fact that perfect surgical technic is not the only prerequisite to the successful treatment of surgical diseases and as this seems to be approaching the limit of its development, other requirements have sprung more prominently into view.

Proper medical treatment to raise the patient's resistance to a higher pitch is important when the time for operation can be postponed sufficiently long. Preoperative roentgen-ray or radium treatment, to limit or reduce the extent of malignant disease before an attempt to remove the growth, is being recognized more and more, as well as postoperative roentgen-ray treatment to prevent recurrence or metastases. Other points might be mentioned here, but it is the purpose of this paper, write Mason and Konrad, to emphasize the importance of the choice of the anesthetic, and to enlarge particularly on paravertebral anesthesia.

TYPES OF OPERATIONS AND COMPLICATIONS.

IN THE TWENTY-SIX CASES in which I performed operation, all the patients have been considered poor surgical risks, either from the standpoint of the operation or the anesthesia or both, and have been thus selected.

My first two cases[1] have been previously reported and will be merely mentioned here. There were in my series the following operations: three extensive perineal repair operations; five perineal repairs combined with laparotomy; one cesarean section in the eighth month of pregnancy combined with cauterization of the cervix for carcinoma; one complete hysterectomy for carcinoma of the cervix; one complete hysterectomy preceded by cauterization and inversion of the cervix; one panhysterectomy for carcinoma of cervix; one cesarean section combined with resection of the tubes; four hysterectomies combined with appendectomy; one resection of the ovaries, appendectomy and curettage; two therapeutic abortions by vaginal cesarean section in the third mouth of pregnancy for pernicious vomiting of pregnancy; three simple curettages; one forceps delivery; one radical operation for an extensive postoperative ventral hernia; one exploratory laparotomy for general carcinosis.

The complications were as follows: extreme anemia from prolonged bleeding of a carcinomatous cervix complicating pregnancy in the eighth month; active tubercular process in both lungs in a case of complete procidentia of the uterus; general debility and old age; mitral stenosis with a blood pressure of 240 mm. mercury complicating fibroids of the uterus; chronic alcoholism; toxemia of pregnancy with vomiting; protracted labor; diabetes and chronic nephritis; chronic myocarditis; and a case of ether idiosyncrasy in which a previous attempt at operation had to be interrupted because the patient went into a state of collapse soon after the anesthesia was complete.

EFFECTS OF ANESTHESIA.

IN NONE OF THE twenty-six cases did there occur any untoward symptoms from the anesthesia except, possibly, in the case of chronic alcoholism.

Case 1.—This patient has been under treatment for ulcerating procidentia of the uterus for thirty days before operation was attempted. During this period she at times showed cerebral irritation as seen in delirium tremens. About a day after the operation these signs became aggravated and on one day required mild restraint. The abdominal wound became superficially infected and healed slowly but completely. The patient was put under bromid treatment for her cerebral condition. Sixteen days after the operation the submaxillary glands became swollen and she died the next day with pneumonia, probably hypostatic, of both lungs. One other patient died on the tenth day after the operation of strepto-

1. Konrad, Frank: Paravertebral Anesthesia, Boston Med. and Surg., Jour., 1917, Vol. 176, 351-353.

coccemia, apparently due to an old pelvic inflammation revived by the repair of the cervix.

Case 2.—The patient was a woman, aged 60 with a huge postoperative ventral hernia of about 6 quarts capacity, which had been developing for twenty years since tbe laparotomy. This patient had passed through several clinics, including the one in which the operation had been done, and was regularly refused further treatment because of ber general condition, age and the size of the hernia. Her usual weight was 140 pounds or more; her present weight was 100 pounds and her appearance was that of 80 years instead of 60, and cachectic. Observation in the ward later seemed to indicate that her loss of weight and cachexia were due to starvation rather than anything else. After ten days in the ward, sbe was operated on under paravertebral anesthesia. She made an uneventful recovery and was discharged well after twenty-one days. The hernia consisted of bowel and omentum which had passed througb an opening in tbe deep fascia sligbtly larger than a silver dollar, and was distributed over the anterior abdominal wall in huge multiple serous pockets. Tbese were dissected and the opening closed by overlapping the fascia.

The immediate operative mortality was nil and since, in all these cases, the patients were at best but fair operative risks, and some were absolutely bad risks from every standpoint, there can be only two possible deductions made, namely, that either my technic was such as to reduce or eliminate shock, or this was accomplished by the anesthesia. I am willing to concede some of the honor to the anesthesia.

The reduction of shock was most marked, as was also the absence of the usual postoperative complications. Vomiting occurred only twice, and that after the therapeutic abortions for toxemia of pregnancy. This seemed only the natural vomiting due to the toxemia, and gradually diminished after the cause of the toxemia was removed. Headache and backache were conspicuous by their absence. Distention was absent, but in relation to this I wish to mention that we have been omitting the common practice of drastic catharsis and bowel lavage which has been in vogue, and this may in part account for the absence of postoperative distention. The patients rarely had any unpleasant memories of the preparations for the operation or of the anesthesia. Occasionally they remembered having felt the prick of several needles, and in the majority of cases, these "needles" proved to be the subcutaneous injections for the preliminary seminarcosis and not those of the back. Often nothing was remembered from the time the barbital was given on the night before the operation.

One exception must be made here.

Case 3.—Tbe patient, a very fat and nervous woman, was anesthetized from the eighth dorsal segment down through tbe sacral segments, with the exception of the fourth and fifth lumbar segments. Sbe evidenced a considerable amount of pain at the injections in the back and when the anesthesia was finished seemed very alert, though the preliminary scopolamin and a mixture of morphin and narcotin had been given. A curettage was, however, done apparently without being noticed by tbe patient, though she at this time recognized low spoken voices. A median laparotomy incision was made without any evidence of pain, but wiping in tbe wound caused pain, and from this time on in the operation it was necessary to give ether to keep her quiet. The appendectomy and resection of the ovaries bound down by adhesions required one hour. During this time she received about 2 ounces of ether by the open method, a very small amount for the operation. After the operation, the patient bad only an imperfect memory of the events preceding the operation and only vaguely remembered having been given ether. There was no vomiting. Tbis case was the nearest to a failure that I had observed, though I believe that even in this case, in which a small amount of ether had to be given, the paravertebral anesthesia reduced tbe amount of shock. The patient had a chronic bronchitis.

NECESSITY OF ADDITIONAL ETHER.

IN FIVE OF MY twenty-six cases it seemed necessary to give additional ether at some point during the operation. The amount necessary varied from a few whiffs to 2 ounces, and in no case was it sufficient to produce any undesirable accessory effects. Later experience taught me that in three of these the ether might have been dispensed with without danger to the patient or inconvenience to the operator. Packing back the intestines occasionally causes a disturbance either on account of too much pulling on the mesentery or by pressure on the diaphragm. This difficulty is easily overcome by a more gentle manipulation of the pack, or, if it does occur, by a few whiffs of ether. To make a perfect paravertebral anesthesia requires not only a complete anesthetization of all the nerves that enter into the field of operation, but also a certain technic in the operator. Though my first few patients were anesthetized completely to my satisfaction. I found that with experience in operating with this method the number of cases in which it became necessary to give additional ether diminished. I do not consider the necessity to give a negligible quantity of ether at some point during the operation as a failure of the anesthesia and never should hesitate to give it in order to keep my statistics clean. On the contrary, particularly in the earlier attempts, I should consider it wise to add the ether at any time there seemed to be any indication for so doing. Occasional groaning or movement, if indicative of pain, is usually not registered or remembered as such. It must be remembered that only the field in which the operation lies is fully anesthetic, and that pulling or tugging on the tissues, particularly the mesentery, is carried to areas beyond the border of the anesthesia and therefore sensed by the brain. In a certain class of patients, this sensation, whatever its nature, is registered as pain and the usual exhibitions of pain, crying or struggling, are brought out. These exhibitions should be suppressed wholly or in part by the preliminary seminarcosis with scopolamin and a mixture of morphin and narcotin or scopolamin and morphin. The degree of seminarcosis necessary for a given case should be gaged by the nature of the operation and by the psychic stability of the patient. It is impossible to establish an infallible rule to fit all cases and experience alone can perfect the method with any given administrator.

II. REPORT ON PARAVERTEBRAL ANESTHESIA.

PARAVERTEBRAL ANESTHESIA is essentially a nerve trunk anesthesia in which the nerve trunk is blocked at or near its exit through the intervertebral foramina. As the nerve emerges from the spinal canal, it passes out along the lower border of the rib, or spinous process, and supplies a definite segment. The patient is placed in the sitting position (Fig. 1) with the back slightly arched, and the skin is prepared by being cleaned with alcohol and painted with iodin. The iodin is applied by drawing transverse lines across each spinous process and two parallel lines vertically downward about 4 cm. out from the midline along either side of the spinal column (Fig. 2). By locating the sixth dorsal spine on a level with the angles of the scapula and the third lumbar spine on a

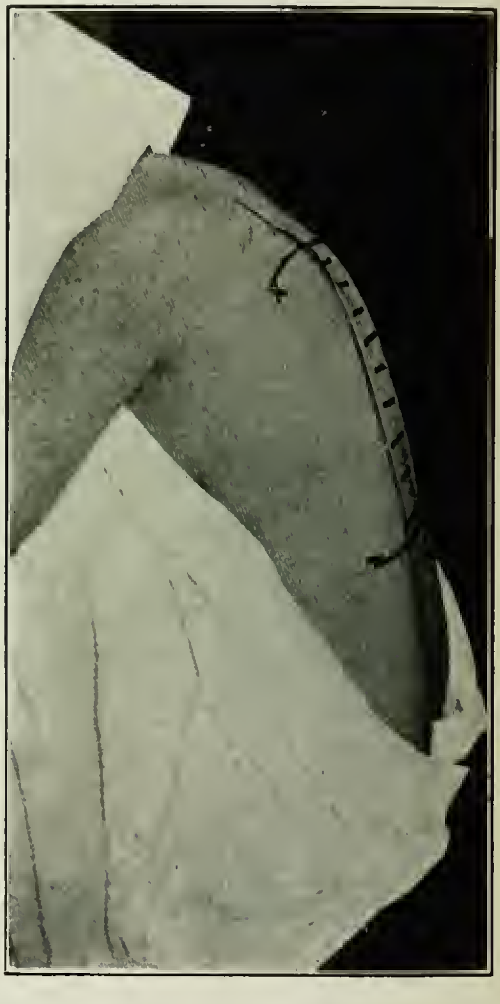

Figure 1.

level with the iliac crests, the anesthetist may locate all the desired segments. A needle introduced at the intersections of the transverse and vertical lines strikes the rib belonging to the spine next above because the ribs join the spinal column at an angle. The surface of the rib should always be located with the needle point, the needle withdrawn nearly to the skin and reintroduced at an angle so as to allow it to pass just underneath the lower border of the rib, and pushed about three-fourths cm. deeper (Fig. 3). The depth is gaged by fixing a point on the shaft of the needle with the fingers when the needle

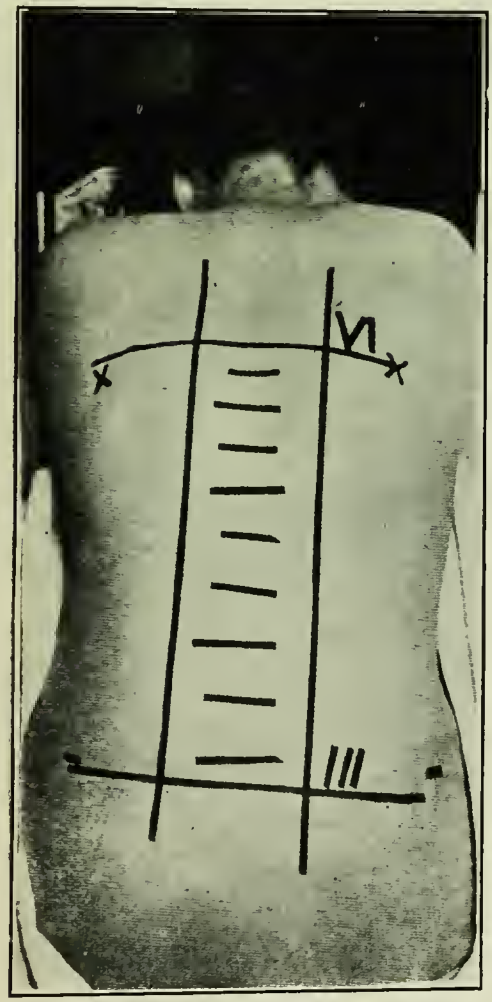

Figure 2.

point rests on the surface of the rib and then pushing the needle into the depth thus fixed. The needle point must now lie in the intercostal space. Fifteen cm. of a 0.5 per cent. solution of procain with 1:1,000 epinephrin in physiologic sodium chlorid solution is injected while the anesthetist slowly withdraws the needle through the space of 0.75 cm., thus infiltrating the whole space and enveloping the nerve that lies within it in the anesthetic fluid. The injections may be made quite painless, even in a fairly conscious patient, by compressing with the finger the point at which the needle is to be inserted until it becomes anemic and then quickly inserting the needle. The same procedure is followed in anesthetizing each segment.

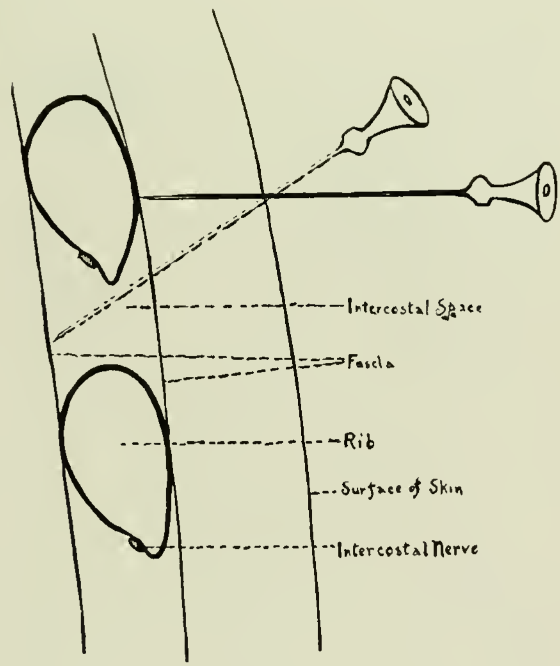

Figure 3.

In the case of the cervical segments I have deemed it safer to go in from the side of the neck along a line drawn from the mastoid process to the acromial process (Fig. 4), because the vertebral artery is more likely to be injured by the needle when it goes in from behind. The integument of the neck and shoulders is supplied principally by the fibers from the second, third, fourth and fifth cervical nerves. The phrenic nerve has its origin almost entirely from the fourth cervical segment and might be a source of concern, but I have anesthetized these segments on both sides at once, without noting any serious respiratory difficulty from paralysis of the diaphragm. The cranial nerves that pass down the neck lie anterior to the sternocleidomastoid muscle and the fluid injected posterior to its border in anesthetizing the cervical nerves is separated from them by dense muscles and by their fascia, the scalene group and other muscles of the neck, so that the danger of blocking these is quite remote, if reasonable care is used.

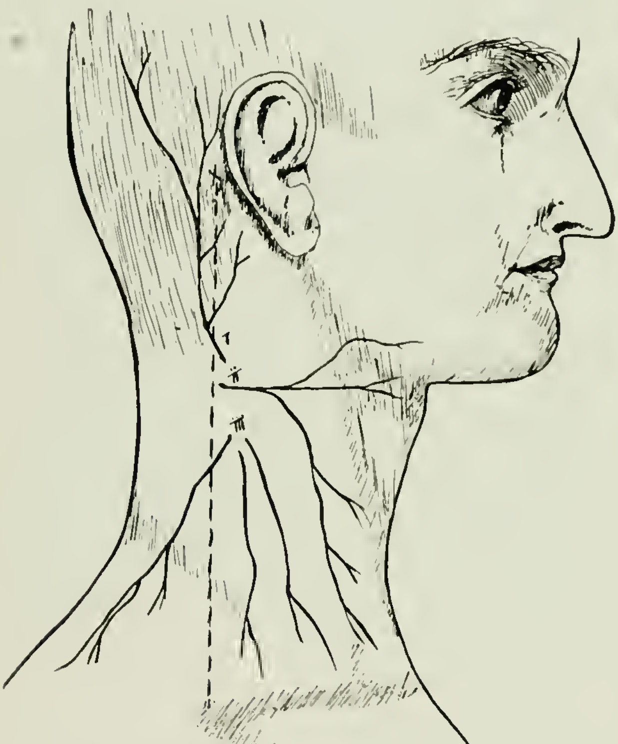

Figure 4.

To reach the sacral nerves, a slightly different procedure is followed. The patient is placed in the exaggerated lithotomy position (Fig. 5), the tip of the coccyx located at a point from 1.5 to 2 cm. out from it is marked with iodin. A needle 15 cm. long is introduced at these points and pushed forward parallel to the horizontal and sagittal planes of the body till it meets an obstruction. This occurs usually at a depth of about 8 cm. from the tip of the coccyx and the needle's point lies at or near the second sacral foramen (Fig. 6). Injections are made while the anesthetist slowly withdraws the needle nearly to the skin, thus infiltrating in a line over the second, third, fourth and fifth sacral nerves

Figure 5.

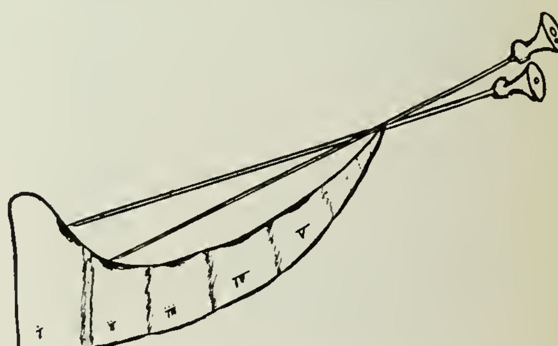

Figure 6.

as they lie in the hollow of the sacrum. The curve of the sacrum here is so shallow that it is unnecessary to change the angle of the needle to reach the lower segments, though this might be done to strike these segments more accurately. In order that the first sacral segment may be reached, the needle is withdrawn nearly to the skin, depressed about 10 degrees and pushed forward again until it meets an obstruction. It now passes 2 or 3 cm. deeper than in the first position and lies at or near the first sacral foramen. The injections are made by withdrawing the needle through this space only. For the sacral segments, it is safer to use 20 cc. of a 0.5 per cent. solution, because the nerves are not in a trunk as definitely circumscribed as in the upper segments, and are more surely to be anesthetized by the larger amount of fluid. In extensive perineal operations it is well to inject 5 cc. on each side between the tip of the coccyx and the rectum to anesthetize the anococcygeal nerves which occasionally cause trouble if this is omitted.

PREPARATION FOR OPERATION.

I USE NEEDLES 0.9 cm. in diameter and 6, 8, 10 and 15 cm. long respectively for the dorsal, lumbar and sacral segments. The shoulders of the needle are made to fit between two fingers and to receive a slip-in butt of the syringe, such as the record syringe. The syringes are of 5 cc. in capacity, and all metal and are a development of the Freiburg clinic.

A record syringe serves the purpose, but one of small capacity insures slow injection and a more even infiltration of the fluid. To obtain the best results, it is well to remember that, though only semiconscious, the patient can still see and hear, and that when anesthetized, parts of the body outside of the anesthetized field are still normally sensitive. A patient once roused out of his semiconscious state by violent stimuli as of bright light, loud noise or ungentle handling has a tendency to show the mild delirium or excitation so frequently ascribed to scopolamin alone. Such a patient, too, is more likely to resent sensing anything during the operation and be restless. Isolation, quiet and subdued light or a bandage over the eyes and ears should be used as a precaution.

The patient is prepared as follows: All preliminaries, such as preparing the field of operation, or giving enemas, should be done before 10 o'clock on the night before the operation. Unless the patient has been constipated, bowel lavage after this time is unnecessary. An unduly distended rectum, however, may obstruct the course of the left needle in injecting the sacral segments; the empty bowel evades the needle point, and therefore the lower bowel should be fairly empty when these segments are to be anesthetized. At 10 o'clock at night the patient is given 10 grains of barbital by mouth. If the operation is to occur late in the morning, 5 grains of barbital may be given again in the morning. Two and one-quarter hours before the operation is to begin, the patient is given 0.0003 of scopolamin and .03 of a mixture of morphin and narcotin subcutaneously. This same dose is repeated after three-quarters of an hour. The injections of procain are begun about one hour before the operation, according to the time required to make them. Fifteen minutes should elapse after the injections are made before the operation is begun. If the patient is restless, one-half the first dose of scopolamin and a mixture of morphin and narcotin may be repeated one and one-half hours after the last injection of these drugs. Morphin, heroin, pantopon (pantopium hydrochloricum) or other soporific may be substituted for the mixture of morphin and narcotin, though I think none are as safe as the latter.

The anesthetic employed is the meconic acid derivative of morphin and narcotin in equal proportions, and has the advantage over the other soporifics in that it does not depress the respiratory centers in the same degree. It is tolerated better and does not show the same degree of variations of effect in different individuals.

The dosages given are the average. Danger, if any, lies in the scopolamin, because of the uncertain stability and potency of the various commercial preparations. It is well to become acquainted with one given preparation and use this always, and in fresh solutions. Age, cachexia, weight under 100 pounds and alcoholism are indications for smaller doses. If in doubt as to the tolerance of the drugs in a given case, the anesthetist will find it well to begin with one-half the dose. Renal, thyroid and pregnancy toxemias bear it well. The amount of physiologic sodium chlorid solution injected with the drug is equivalent to a hypodermoclysis.

Points to be remembered in operating are that the packing back of the intestine against the unanesthetized diaphragm in laparotomies may cause temporary respiratory difficulty, and distress the patient. Also, pulling on the mesentery in mobilizing the bowel or placing the pack improperly causes pain by propagation into sensitive fields. Both these difficulties may be avoided by slow and careful packing back of the intestines, or omitting the pack when possible. The abdominal muscles usually show a marked degree of relaxation and the wound gapes without retractors. Too severe pulling on the retractors likewise may cause pain by propagation into sensitive areas. Gentle manipulation of all tissues and elimination of noise will be rewarded by better results both in the operation and in the anesthesia.

In controlling the efficiency of the anesthesia by questioning after the operation, the anesthetist will sometimes find it difficult to get at the facts. There frequently remain islands of memory of the course of the operation and from these some patients will reconstruct a picture that closely resembles the actual facts. In my tables I have put such cases under the heading of partial failures.

The scopolamin occasionally causes an annoying lip dryness. This may easily be combated by administering water, even during the operation, and it is well to do so to prevent an occasional hoarseness afterward; a coating of petrolatum over the lips will obviate their cracking. There is no after-treatment necessary on account of the anesthesia, such as abstention from food and drink as in the case of ether. Unless there exist conditions other than those due to the anesthesia, patients may be put on regular light diet immediately after the operation. The administration of both food and drink early prevents the weakness from depletion and hastens the convalescence.

RESULTS OF OPERATIONS.

THIS PAPER COVERS the observations of 107 anesthesias on 105 patients. Table 1 indicates the operations performed.

TABLE 1.—LIST OF OPERATIONS.

Forceps delivery	29
Abdominal cesarean section	4
Craniotomy	4
Dilatation and curettage	8
Primary perineal repair	11
To relieve the pain of labor	1
Colpoperineorrhaphy	11
Ventral suspension of the uterus	5
Resection of both ovaries	1
Complete and supracervical hysterectomies	13
Appendectomy	6
Cauterization of the cervix	1
Suprapubic cystostomy	1
Thyroidectomy	3
Excision of the mammae	1
Amputation of the breast with dissection of the axillary glands	1
Amputation of the leg above the knee	2
Gastro-enterostomy	1
Decapsulation of the kidneys	1
Radical repair of postoperative abdominal hernia	1
Radical repair of inguinal hernia	6
Orchidectomy	2
Suprapubic prostatectomy	1
Exploratory laparotomy	3
Interposition operation for uterine prolapse	1
Vaginal cesarean section	2
Kraske operation	1
Resection of ribs	2
Cholecystectomy	3
Salpingectomy	3
Cauterization of hemorrhoids	1

In thirty-three obstetric cases, there were no maternal deaths and four fetal deaths, three after forceps operation and one after cesarean section. The cesarean section was performed on a woman in the eighth month of pregnancy and suffering with extensive carcinoma of the cervix. The baby cried immediately on delivery, but died eight hours after. Indications for the forceps operations were danger to the fetus. Two were dead at delivery and the other died two and three-quarter hours after delivery. This is a high fetal mortality, even for operative cases, and might be ascribed at least in part to the delay necessary for the administration of the anesthesia. It should therefore not be used unless there is sufficient time to accomplish it without seriously endangering the child.

Among the cases with operation, there have occurred to date eleven deaths, nine before discharge from the hospital and two after discharge. Table 2 shows the time of death, the number of deaths and the apparent causes of deaths:

TABLE 2.—MORTALITY IN CASES WITH OPERATIONS.

Condition	Operation	Exitus Letalis	Cause
Hypernephroma......	Exploratory kidney and laparotomy	8 hours P. O.	Cachexia Exhaustion
Diabetic gangrene . .	Amputation	37 hours P. O.	Diabetic coma
Diabetic gangrene . .	Amputation	44 hours P. O.	Diabetic coma
Mercuric chlorid poisoning........	Decapsulation	28 hours P. O.	Toxic coma
Carcinoma of rectum	Kraske operation	3 days P. O.	Volvulus
Prolapse............	Colpoperineorrhaphy	10 days P. O.	Streptococcemia
Lung abscess........	Resection of ribs	10 days P. O.	Septicemia
Prolapse	Laparotomy and plastic	17 days P. O.	Alcoholic edema of the brain (static pneumonia)
Gastric carcimona . .	Gastroenterostomy	24 days P. O.	Cachexia
Inguinal hernia.......	Repair of hernia	....	
Tubercular testis....	Orchidectomy	7 weeks P. O.	Phthisis
Uterine carcimona. .	Hysterectomy	4 months P. O.	Cachexia

Case 4.—The first death, which occurred eight hours after operation, was that of a woman, aged 78, with a large palpable tumor in the right upper quadrant. The kidney on this side showed no secretion on ureteral catheterization and the diagnosis of hypernephroma was made. Under paravertebral anesthesia, a right kidney incision was made and a small compressed kidney was found and left. The incision was closed and a right rectus incision was made. This revealed an extensive growth involving the gallbladder, liver and adjacent tissues. There was also a considerable amount of ascitic fluid in the abdominal cavity. The incision was closed without an attempt to remove the tumor and the patient was removed to bed. The operation and the anesthesia were accomplished without any untoward event, and after the operation the patient had a strong pulse rate of 90 per minute and a respiration rate of 15 per minute. She was left with directions for stimulation with hot coffee and fluids by mouth. I did not see her again, but was told that she died eight hours after operation without having fully regained consciousness. In this case the anesthesia must be considered at least a contributory cause of death.

In two cases of diabetic gangrene of the lower extremity and amputation above the knee, the patients died thirty-seven and forty-four hours respectively after operation in diabetic coma. Both were extreme cases and ran a septic temperature before operation. Two other diabetics were operated on under this type of anesthesia, one operation being an extensive plastic operation on the perineum and the other a therapeutic abortion on account of an associated chronic nephritis. Neither showed any accessory reaction and both made an uninterrupted convalescence. For the other fatalities, the table is self-explantory.

Vomiting, not including two cases of toxic vomiting of pregnancy which began to subside soon after the interruption of the pregnancy, occurred only twice and was only moderate. Complaint of headache, backache and dizziness could be elicited only in a few cases after the leading questions were asked.

Ninety-four operations were performed on patients under paravertebral anesthesia without additional inhalation narcotics, that is, 87.9 per cent.; thirteen patients received additional inhalation, that is, 12.1 per cent. Of these, ten received ether and three received nitrous oxid. Only two of these thirteen patients later remembered having received any inhalation. It would seem from this that it was absolutely necessary to give an additional anesthetic only twice, and that in the other cases the exhibitions of sensation were overrated.

As all anesthesias of this paper were performed on selected cases, the results must be considered in the light of such selection. Thirty-eight were random cases which might have done well under other forms of anesthesia. In sixty-nine of the cases, along with the condition demanding operation, there existed other pathologic conditions which made the administration of the usual inhalation narcotics precarious. These conditions formed the basis for the choice of paravertebral anesthesia. They include practically all those commonly encountered, and so far, I have been unable to find any contraindication to its use, except when an immediate anesthesia is required. It is applicable to all surgery from the neck down. In head surgery, it might be applied as trunk anesthesia wherever the large sensory nerve trunks are accessible to the needle. The paucity of its accessory reactions and its power to eliminate shock makes it the anesthesia of choice whenever it can be administered. Closer acquaintance with it will remove such objections as consumption of time and technical difficulty.

FRONTAL SINUS OPERATION (LOTHROP) PERFORMED UNDER LOCAL ANESTHESIA . TECHNIC . INCISION . SUMMARY . REGIONAL ANESTHESIA FOR RADICAL SURGERY OF THE MAXILLARY SINUS . NEURO-ANATOMY . TECHNIC OF INFRAORBITAL AND POSTERIOR SUPERIOR DENTAL NERVE INJECTIONS . SOLUTION . ADVANTAGES . LARYNGECTOMY UNDER NERVE BLOCKING . CASE REPORT . ADVANTAGES OF NERVE BLOCKING . SOLUTION AND TECHNIC OF INJECTION . CONCLUSIONS . A SIMPLE METHOD FOR THE REMOVAL OF MODERATE SIZE VESICAL CALCULI UNDER LOCAL ANESTHESIA . TECHNIC OF THE ANESTHESIA AND SURGICAL PROCEDURE .

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LOCAL AND REGIONAL methods of anesthesia are coming into use in the specialties when they offer certain advantages to the operator or the patient. At best frontal sinus operations are difficult procedures and M. P Boebinger of New Orleans, La., speaking before the Orleans Parish Medical Society, January 28, 1918, and publishing his technic in the New Orleans Medical and Surgical Journal, emphasizes the utility of this method in cases of pan-sinusitis.

The object of this paper is to report a case of pan-sinusitis in which all previous methods of treatment had failed and in which relief resulted from operation under local anesthesia. The case had been previously treated by Douglas puncture of the left antrum only and frequent washings without result. Later a Caldwell-Luc was done on the same antrum, with likewise negative result. When first seen by the writer a diagnosis of pan-sinusitis was made, and the opinion expressed by him that the antrum was simply acting as a reservoir for trouble higher up.

The diagnosis was made by observing the flow of pus on both sides, coming from above and below the middle turbinate, as well as pus upon the posterior wall of the pharynx. Trans-illumination showed darkness for both frontal sinuses and right maxillary. This diagnosis was further corroborated by the findings of Dr. Adolph Henriques upon x-ray examination. Only the application of cleansing agents was made until the date of operation, November 22, 1917.

On this date the case was prepared for frontal sinus operation under local anesthesia, a full breakfast being given and morphin sulph., gr. 1/4, being injected fifteen minutes before operation.

TECHNIC.

PLEDGETS OF COTTON were introduced into each nasal chamber, being first soaked with cocain hydrochlor., 10 per cent. solution, and adrenalin chlorid, 1 to 1,000, the excess being expressed. After an interval of fifteen minutes the cotton was removed; the agger-nasi region was then rubbed with swab moistened with the same solution. This swabbing was repeated a few times, the mucosa about the frontal openings, as well as the middle turbinate and the anterior wall of the sphenoid, being similarly anesthetized. A Mosher operation on the ethmoid labyrinth, modified so as to include the removal of the middle trubinate, was now done on the left side, including the removal of the anterior wall of the sphenoid.

The upper septum was next well swabbed with cocain and adrenalin solution. After an interval of ten minutes, in order to block off the nerve supply, one drachm of novocain solution of ¼ per cent. strength was injected high up into the septum just beneath the frontal sinus floor.

The skin and unshaven eyebrow were cleansed with alcohol and iodin prior to anesthesia. One drachm of ¼ per cent. solution of novocain was injected beneath the skin of the left eyebrow, about one-quarter inch from its mesial margin, then deeper into the superficial tissue, and finally beneath the periosteum. The supraorbital, supratrochlear, infratrochlear branches were then injected. The entire anesthesia about the frontal sinus externally was done with a single skin puncture, with a two-inch needle, withdrawing the needle just far enough to inject each succeeding area, but not withdrawing it entirely out of the skin.

INCISION.

A ONE-INCH CURVED INCISION was made through the left eyebrow, beginning at the inner margin of the eyebrow and closely following its curve, avoiding injury to the supraorbital nerve, which might result in para-esthesia, or numbness, along its course. The incision was deepened to reach the bone. A Jansen mastoid retractor was placed after elevation of the periosteum. The reason for using this particular retractor, or any mastoid retractor, for that matter, was to secure a bloodless field—a point noted by the writer on former occasions, and which could not be produced by the use of the ordinary eye or hand retractor. Besides this, the aid of an additional assistant is rendered unnecessary, as well as avoiding the unnecessary use of instruments in an already crowded small field of operation. A very small gouge was used to make the first opening into the sinus at a point corresponding to the usual position of the interfrontal septum, thus rendering later access to the interfrontal septum more easy. The opening was enlarged by means of up-cutting forceps, to an oval about three-quarters inch long at its long diameter. Upon inspection through this opening, polypoid tissue was seen to fill the entire sinus.

A point to be noted here is that, whereas ordinarily it is usual and necessary to apply cocain to the mucosa of a sinus operated upon under local anesthesia, as, for example, in a Caldwell-Luc operation, in this case it was unnecessary, on account of the successful nerve-blocking. The mucous membrane was curetted without the least evidence of pain on the part of the patient. The next step was to break through the interfrontal septum and enlarge the opening by means of gouge and burr. Following this, the same procedure as on the left sinus was adopted—that is, curettement. Attention was next directed to breaking through the floor of the frontal sinuses and the perpendicular plate of the ethmoid by means of gouge, burrs and rasp (the latter being of the writer's design). A large opening was thus produced leading into the upper nasal cavity, constituting an easy means of approach for subsequent treatment. No post-nasal pack was used, as is customary in a frontal sinus operation under general anesthesia, as the patient was awake and the bleeding from the mucosa was easily controlled by the suction apparatus. The incision was closed as usual, no pack being used for drainage. A tight compress head bandage was applied. The patient was sent back to his room ready for his noonday meal, which he ate with apparently no ill after-effects, no nausea being experienced. In twenty-four hours the outer dressing was removed, as it felt a little tight. On the second day the patient was out in the rolling-chair, as he showed no temperature, nor did any develop subsequently. On the fifth day the sutures were removed, the incision healing by first intention.

SUMMARY.

In summarizing, the following points are to be noted:

1. No pain was felt by patient at any time during operation.
2. No postoperative nausea was experienced.
3. Patient was up and about earlier than with general anesthesia.
4. On the part of the operator, it was unnecessary to cocainize the frontal sinus mucosa.
5. No postnasal pack was necessary—a matter of increased comfort for the patient and lessening the danger of middle-ear disease from retained secretion and irritation of the gauze.
6. There was very little reaction about the eyelid.

To the writer's knowledge, this is the first case of frontal sinus operation done under local anesthesia to be reported from this section.

PUBLISHING HIS PROCEDURE in the Laryngoscope, August, 1918, Lawrence Gatewood of New York City, lays stress on the fact that radical surgery of the maxillary sinus may be readily, painlessly and satisfactorily performed under regional anesthesia of the infraorbital and posterior superior dental nerve trunk. In considering this procedure, Gatewood, emphasizes the necessity of paying strict attention to the neuro-anatomy involved.

ANATOMICAL CONSIDERATIONS.

THE INFRAORBITAL and posterior superior dental nerves, branches of the maxillary, are the nerves supplying this region. A study of their location and distribution will convince the reader that it is quite possible to completely anesthetize this region by injecting a local anesthetic into the vicinity of the trunks of these nerves.

The maxillary nerve passes through the infraorbital sulcus and canal to the infraorbital region of the facial surface of the maxilla, giving off numerous branches in its course. In passing through the infraorbital canal it gives off the superior dental branches at various intervals through the minute canals in the body of the maxilla. The middle and anterior superior dental branches are given off near this point and supply the alveolar process, sending off small twigs to the teeth.

Before entering the canal the maxillary nerve gives off the posterior superior dental nerves to the maxillary tuberosity which partly follow the arteries, partly pass through their own foramina into the tuberosity and the body of the maxilla. Following the arteries they pass forward above the molar teeth, branching out within the facial wall of the maxilla and finally communicate with the middle and anterior superior dental nerves. They supply the oral mucosa, the molar teeth, the mucous membrane which lines the maxillary sinus and the periosteum.

The infraorbital nerve frequently divides into from two to four branches, which arise closely together from the infraorbital foramen. They run behind and above to forward and inward. Their numerous subdivisions form a thick nerve plexus, which in turn sends off finer branches to the oral mucosa, the floor and the lower lateral aspect of the nasal cavity and the incisor and canine teeth.

From the above description of the nerve distribution it is clearly seen that anesthesia of this region may be easily brought about by the injection of a local anesthetic into the vicinity of the infraorbital and posterior superior dental nerve trunks. This solution, penetrating by way of the perineurium into the central nerve substance, inhibits its function and anesthetizes the peripheral area supplied by these nerves. Owing to the elimination of the conductivity of these nerve trunks, sensory irritations of their terminal filaments are no longer perceived in the central organ and the anesthesia is complete.

TECHNIC OF NERVE BLOCKING.

THE TECHNIC FOR BLOCKING these nerves is as follows: To inject the infraorbital nerve, the infraorbital canal is palpated with the index finger, this being located two-fifths of an inch below the middle of the infra-orbital ridge; the finger is kept on this point. With the thumb of the same hand the lip and check is drawn up to expose the field of operation. The needle is inserted into the buccal fold slightly distal to the apex of the canine teeth, care being exercised to avoid penetrating the alveolar process. The needle is now passed upward and slightly inward for three-fifths of an inch, infiltrating the tissues slowly as the needle is advanced. Having inserted the needle to the distance above stated, we are now in the region of the infraorbital canal of the facial surface of the maxilla. Here the remainder of the anesthetic solution is deposited, this being felt by the index finger. Gentle massage of this area will hasten the absorption of the anesthetic, producing proper anesthesia of this nerve and its branches.

Technic for injecting the posterior superior dental nerve: This injection is guided by the condyle of the palate process of the maxilla. The point of insertion of the needle is in the buccal fold corresponding to the middle of the disto-buccal root of the second last tooth from the condyle, this being the first or second molar respectively, depending upon the presence or absence of the wisdom tooth. The needle is now passed upward, backward and slightly inward, passing over the apices of the buccal roots of the second or third molar, as the case may be, using an angle of about forty-five degrees to the acclusal plane of the teeth. The tissues are infiltrated slowly as the needle is pushed forward and the remainder of the anesthetic solution is deposited after the needle has disappeared for about four-fifths of an inch.

ADVANTAGES.

THE ADVANTAGES OF regional anesthesia over the infiltration method are: (1) Less anesthetic is required. (2) Anesthesia is produced with less discomfort to the patient. (3) The duration of the anesthesia is longer. (4) Less trauma is produced and the danger of infection is not so great.

Procain is the anesthetic of choice in this field of work. For each injection 2 cc. of a 2 per cent. procain solution are used. This may be considered a rather high strength but Gatewood is convinced that taking into account the very small quantity of solution necessary to produce complete anesthesia, toxic complications are much less likely to occur than when larger quantities of a weaker solution are injected by the infiltration method.

LARYNGECTOMY IS AT BEST a difficult and precarious operation under any method of anesthesia. In pursuing his work in local and regional anesthesia in the Clinics of the Alexian Brothers Hospital and the Post-Graduate Medical School, Malcolm L. Harris of Chicago, Ill., reports the successful use of nerve blocking in this procedure and his present exposition of his technic is taken from the Surgical Clinics of Chicago.

THE OPERATIVE CASE.

THE CASE TO BE OPERATED, presents the following history, omitting unessential details: F. K., age forty-seven. He has been feeling poorly for the past six months, during which time he has complained of a sore throat, cough, and difficulty in swallowing. He has had a mucopurulent sputum, streaked with blood, which has become quite profuse of late. For the past month he has been unable to swallow without great pain, and about three weeks ago he lost his voice, so that now he can speak only in a whisper. His appetite is poor and he has vomited after eating several times recently. He says he has lost about 60 pounds in weight. His general appearance is bad, he is poorly nourished, shows a great loss of weight, and his muscles are flabby. The important part of the physical examination, so far as we are now concerned, relates to the larynx. This is found to be filled with a nodular ulcerated mass. The right vocal cord is entirely destroyed and the left one paralyzed. The mass so fills the larynx as to cause a marked stenosis. There are a few palpable, enlarged, hard lymph-glands on either side, particularly the left, in the upper anterior triangle of the neck.

ADVANTAGES OF NERVE BLOCKING.

A DIAGNOSIS OF advanced carcinoma is unmistakable, but notwithstanding the advanced stage of the disease and the poor general condition of the patient, the stenosis is so marked and the dyspnea so intense that an operation is imperative in order that he may have relief. A simple tracheotomy would give relief so far as the dyspnea is concerned, but we feel that the patient should be given a chance at least for that greater relief which may come from a more radical operation, and this, too, in spite of the fact that a few of the neighboring lymph-glands are already involved. We are also led to the major rather than the minor operation for the further reason that a complete laryngectomy is but little more difficult than a proper tracheotomy. Exception may be taken to this last statement by many who have done laryngectomy by the older method with general anesthesia, and we will agree perfectly with anyone that a complete laryngectomy, done with all the annoyances, difficulties, and dangers of the usual general anesthesia, is a very trying as well as a serious operation, but under nerve blocking the operation is robbed of most of its difficulties and becomes quite simple.

Under nerve blocking the operator is freed from the annoyances inevitably connected with the anesthetist and his apparatus, the tracheotomy tube, and other inconveniences, and can proceed with the operation with a perfectly free field.

TECHNIC OF INJECTION AND SOLUTION USED.

THE NERVE SUPPLY of the anterior region of the neck is well adapted to nerve blocking, and almost all operations involving this region can be performed by this method with great satisfaction. To block this region the needle is inserted just behind the middle of the posterior border of the sternomastoid muscle. The external jugular vein usually crosses this muscle at about that point, so that the needle usually enters just above and behind the point of crossing on the vein and the posterior border of the muscle, but the vein varies somewhat at times, so that it alone is not a reliable guide. The vein, however, should be identified before inserting the needle, so as not to puncture it and thus inject the solution into the vein. The point of the needle should lie just beneath the deep fascia in immediate proximity to the branches of the superficial cervical plexus. Solution used:

Novocain, ½ per cent. ....3 parts
Calcium chlorid, 2 per cent. ....1 part
Magnesium chlorid, 2 per cent..½ part

Mixed at the time of using, and to which about 6 drops of 1:1000 adrenalin solution are added, just before using, to 60 cc. of solution.

The needle being now inserted, as shown in figure 1, 25 cc. of the novocain-calcium-magnesium solution are injected on either side of the neck; 10 cc. of the same solution are next injected on either side, near the outer end of the hyoid bone. In less than five minutes we have a complete anesthesia of the entire region of the neck. An incision is made along the midline of the neck from just above the hyoid bone to the suprasternal notch, and, on account of the enlarged glands on the left side, a transverse incision is made near the upper end parallel with the hyoid bone. The longitudinal incision is carried down at once to the thyroid cartilage above and to the trachea below, exposing the isthmus of the thyroid, which is doubly ligated and divided and the lateral halves pushed aside. A loop of strong silk is passed around one of the cartilaginous rings of the trachea, the trachea completely divided above that ring, and the lower end of the trachea drawn out at the lower angle of the wound. A few drops of the novocain solution are now injected into the mucous membrane of the proximal end of the trachea, and you will notice that there is no evidence of tracheal irritation, no tendency to cough, and no change in the rate or character of the respirations after treating the trachea in this manner. By means of the silk loop about the ring of the trachea the

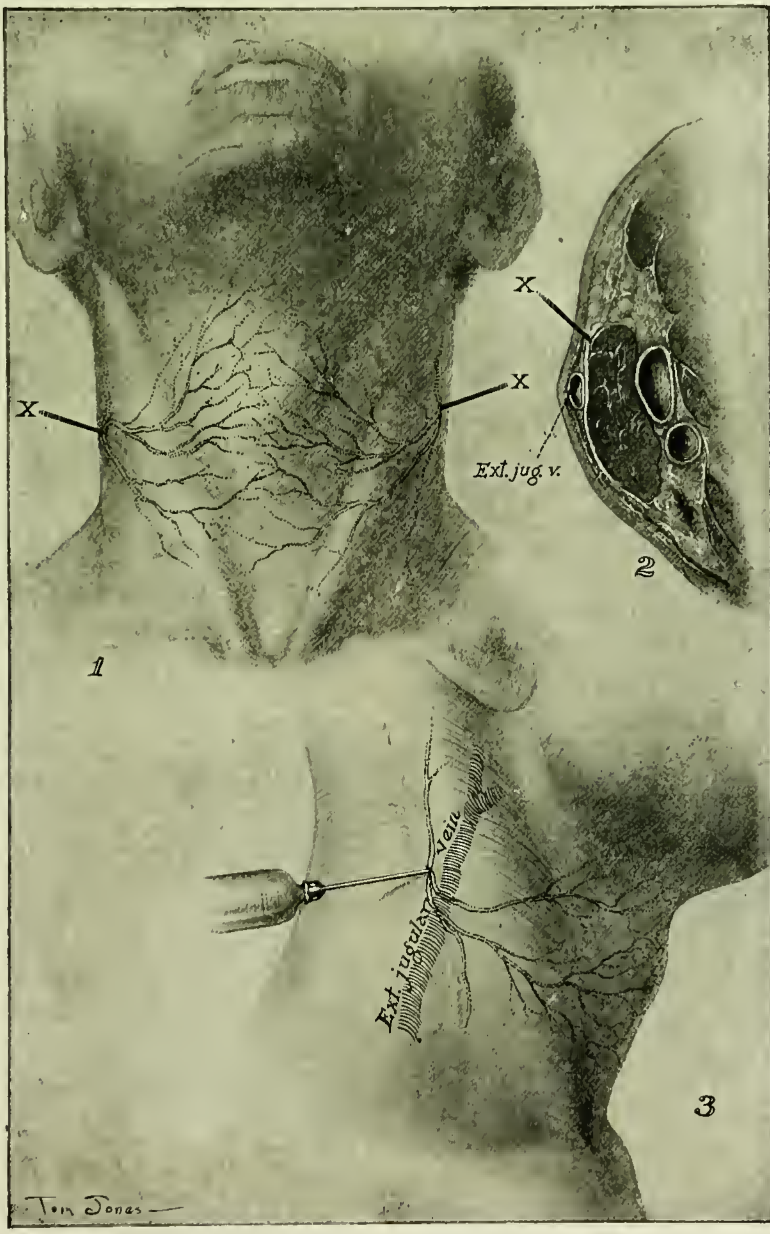

Fig. 1. 1 and 3 show the distribution of the nerve supply of the neck and the point at which the needle is inserted for the injection of the anesthetic. In 2 the position of the injecting needle and the anatomic relations are shown in cross-section. (Courtesy of W. B. Saunders Company.)

end of the trachea can be easily drawn forward out of the lower end of the wound so there is no interference with respiration. The advantage of not being bothered by the anesthetist at this point of the operation is very apparent. On account of the dissection of the upper anterior triangle of the neck, which we intend to make, we turn down and out skin-flaps at the upper angle of the incision.

We now proceed to dissect out the larynx completely, including the tissues and lymph-glands on either side above. On dissecting posteriorly we reach the region of the esophagus and the pharynx, and upto now you will notice that the patient has given no evidence whatsoever that he has suffered the slightest pain, but on cutting the wall of the pharynx he moves his hand as an indication that it hurts. This we would expect, as we are now in a region not supplied by the cervical plexus, but by the glossopharyngeal nerve, so we will now inject a few drops of novocain solution along the wall of the pharynx so as to block this region. In doing this we should be careful not to block pneumogastric nerves. Having made this injection, we proceed with the dissection, and the patient gives no further evidence of pain. The larynx is now completely removed, including the epiglottis and the surrounding tissues. Fortunately, we are able to close off the pharynx in front, which we do with catgut. A drain is placed in the upper end of the wound and the skin closed down through the lower angle, where we bring the proximal end of the trachea to the surface and carefully suture it to the skin, leaving the opening free without the introduction of a tracheal tube.

The patient will be placed in bed and allowed to sit up at once, and will be fed for a few days through a tube.

CONCLUSIONS.

ANYONE WHO HAS UNDERTAKEN, or even witnessed, an operation for the complete removal of the larynx under general anesthesia cannot fail to be impressed by the ease and facility with which the operation can be performed under nerve blocking. As you have seen, there has been no difficulty with respiration, no trouble or annoyance with the anesthetic, and the patient's general condition at the end of the operation shows that there has been practically no shock. His pulse was 90 before starting the operation, and it is only 100 now, the quality and fulness remaining about the same. It is quite evident from his actions during the operation that he suffered no pain, and this, too, notwithstanding the fact that he had no morphin, scopolamin, or other anodyne before the operation, showing conclusively that the anesthesia and freedom from pain were due entirely to the nerve blocking.

This patient recovered from the operation, gained rapidly in weight and general health, and was very comfortable for some months, when internal metastases began to show.

OPINIONS REGARDING the most satisfactory manner of removing calculi from the bladder are as yet quite diversified. Discussing this matter before the Minnesota Academy of Medicine, February 13, 1918, and in the pages of the Urologic and Cutaneous Review, 1918, R. E. Farr of Minneapolis, Minn., observes that small stones may be removed through the urethra, especially in the female, whose urethra may be easily dilated to a considerable size. Very large stones must be crushed or delivered through an adequate incision in the wall of the bladder. The crushing operation is not entirely satisfactory; if done without general anesthesia, it is a rather severe ordeal for the patient, and, in any event, a possible nucleus may be left for the formation of new calculi in its wake, as one cannot be certain that all particles have been washed out.

On account of their great size, or because of such conditions in the bladder as diverticula, encrusted mucosa, or a state of the mucosa which renders visualization impossible, a certain percentage of calculi demand cystotomy. There is, however, especially in the male, rather a large proportion of cases in which the stones are of moderate size and the condition of the bladder sufficiently healthy that the simple removal of the stones, without crushing, and with the minimum injury to the patient, both locally and generally, is desirable. It is for the handling of this class of cases that the following technic has been suggested.

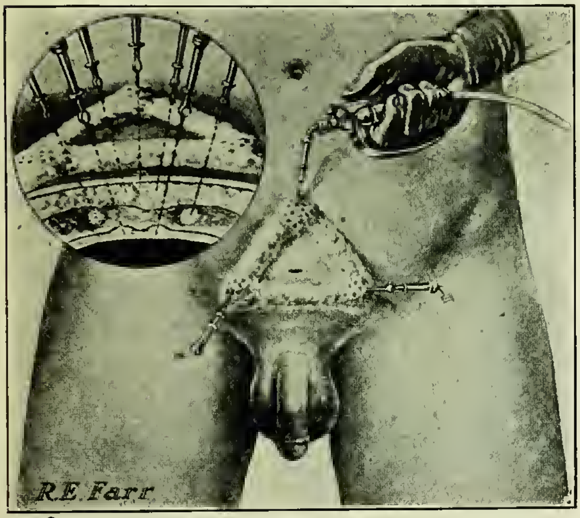

Figure 1.

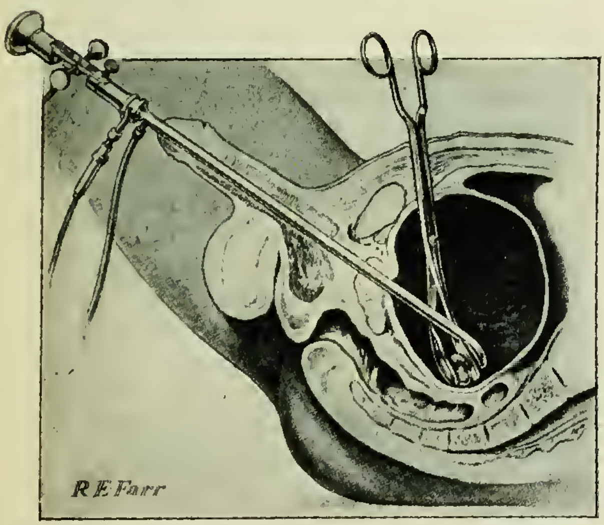

Figure 2.

TECHNIC OF THE PROCEDURE.

THE PATIENT IS prepared as for cystoscopy with the addition of a suprapubic shave. About an hour before operation the bladder is irrigated, and about two ounces of 1 per cent. novocain left *in situ* after a thorough emptying of the viscus. Supra pubic infiltration, including all layers of the abdominal wall and the anterior wall of the bladder, is made over an area about three inches in diameter (Fig. 1). A cystoscope is then introduced, the bladder dilated and orientation established. A stab-wound is then made just above and as close as possible to the pubic bone. With an ordinary or stone-grasping forceps this stab-wound is dilated to

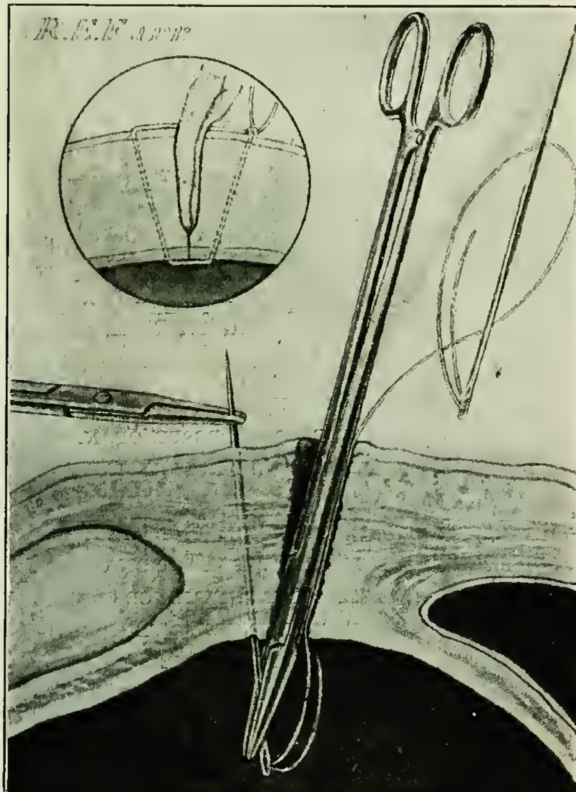

Figure 3.

the approximate size of the stone, which, under the guidance of the assistant looking through the cystoscope, is easily grasped and withdrawn (Fig. 2). The procedure is so easy and can be done so quickly, that collapse of the bladder from the escape of the fluid through the suprapubic wound does not accur. Should there be any delay the fluid may be replenished with sufficient rapidity to enable one to make use of the cystoscope.

The wall of the bladder is sutured in the manner illustrated in Fig. 3. Needles one inch longer than the thickness of the abdominal wall are threaded upon each end of a suture and introduced from within outward as shown. A small wick of iodoform gauze is passed down to the space of Retzius and the suture tied (Fig. 3). The disability is little greater than that following cystoscopy.

The advantages of this procedure are that it is relatively safe, relatively painless and relatively simple. It inflicts upon the patient the minimum of trauma and the period of convalescence is brief.

IN THE COMPLEX MULTIPLICATION OF ULTERIOR CONSIDERATIONS THE SIMPLE ELEMENTARY TRUTHS OF ANESTHESIA APPEAR TO HAVE BEEN LOST SIGHT OF AND TO NEED RESTATING. THE CRUCIAL QUESTION IN ANESTHESIA IS THAT OF COMPARATIVE SAFETY TO LIFE CONSISTENT WITH A SURGICAL DEGREE OF NARCOSIS AND NECESSARY MUSCULAR RELAXATION. THE PROBLEM FOR ANESTHESIA IS TO CREATE AN INTERRUPTION IN THE LONG CIRCUITS, BETWEEN THE PERIPHERIES WHICH ARE TO BE ATTACKED IN SURGICAL OPERATIONS AND THE SENTIENT CENTERS IN THE CEREBRUM, OF SUFFICIENT EFFECTIVENESS TO PROHIBIT A REACTION OF THE FORMER IN THE LATTER BUT NOT SUFFICIENT TO CUT OFF THAT INFLUENCE OF THE LATTER UPON THE FORMER, WHICH IS NECESSARY TO THE MAINTENANCE OF LIFE AND VITAL FUNCTION. THE REAL DANGER IN THE PROCESS LIES IN THE FACT THAT UNDER ANESTHESIA, PROFOUND ENOUGH TO CONFER IMMUNITY FROM SENSATION, THE VITAL FUNCTIONS, TO THE EXTENT OF THEIR ANESTHETIZATION, ARE TEMPORARILY DEPRIVED OF THAT QUICKENING AND EQUALIZING INFLUENCE OF THE BRAIN, WHICH NORMALLY ACTS BOTH AS A SAFETY GAUGE AND AS A GOVERNOR OF THE VITAL FORCES. THAT METHOD OF ANESTHESIA, WHICH WILL ENABLE US TO BLOCK ONLY THAT PARTICULAR CIRCUIT CONCERNED IN THE OPERATION, IS OF COURSE THE IDEAL METHOD. FAILING THAT, OR UNTIL THAT MAY BE ATTAINED, THE METHOD, WHICH AFFORDS THE GREATEST AVAILABLE FACILITY FOR MEASURING AND REGULATING THE DEGREE OF SENTIENT INTERRUPTION AS WELL AS MAINTAINING THE GREATEST DEGREE OF VITAL INTEGRITY OF THE LONG CIRCUITS, MUST BE REGARDED AS THE MOST DESIRABLE SYSTEM OF ANESTHESIA.

—*The Medical Brief.*

CLINICAL METHODS OF TREATING HYPERSENSITIVE DENTINE . HISTOLOGICAL CONSIDERATIONS . PATHOLOGICAL POINT OF VIEW . TREATMENT . PHYSICAL METHODS . APPLICATIONS OF DRUGS . CAUSTICS . ANESTHETICS . PERIDENTAL ANESTHESIA . STERILIZING THE OPERATIVE FIELD . DESENSITIZING PREPARATIONS . HIGH PRESSURE ANESTHESIA FOR CAVITY PREPARATION . NITROUS OXID OXYGEN ANALGESIA . CONDUCTIVE ANESTHESIA . COMPRESSED AIR OBTUNDER . PREPARING POINT OF INJECTION . LIQUID-TIGHT CONTACT . APPLYING ANESTHETIC . ANESTHETICS USED . LOCATING POINT OF INJECTION . SINGLE INJECTION FOR TWO CAVITIES . ILLUSTRATIONS OF TECHNIC FOR HIGH PRESSURE METHODS ADVOCATED .

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IN A CLINICAL lecture delivered before the Kings County Dental Society, October 12, 1916, and later published in the Dental Outlook, May, 1917, Hermann Prinz of Philadelphia, Pa., detailed various methods of treating hypersensitive dentine. It is Prinz's custom to thoroughly investigate a subject before expressing himself and in consequence his observations are always worth while. Prinz considers that:

One of the most profound problems which confronts the routine practice of the dental practitioner is the overcoming of the peculiar condition which we refer to as hypersensitive dentine. The question of hypersensitive dentine naturally interests the general practitioner from the standpoint of its treatment, to a less extent from the standpoint of the pathological anatomy, and to a still less extent from the standpoint of the problem of histological anatomy. Nevertheless, it is possibly of some interest at least, if we will touch even preliminarily upon the underlying factors of pathological anatomy, because without it you will not understand or comprehend the nature of the treatment as readily as you would otherwise.

HISTOLOGICAL CONSIDERATIONS.

AS YOU WILL RECALL from your early studies of histology, the hard tissues of the teeth are composed of three different tissues: the dentine, cementum and the enamel. At this moment the cementum is of less interest to us, because it does not in any shape or form enter into the subject proper. While, on the other hand, the enamel, but especially the dentine, is of vital interest to us relative to the so-called innervation. You remember the enamel as such is composed approximately of about 95 or more per cent. of inorganic material, the rest being organic substances and to some extent water; while, on the other hand, the dentine proper consists of about 72 per cent. of inorganic material, about 10 per cent. of water, the balance being an organic net work of protoplasm. The enamel proper, as far as its organic constituency is concerned, most likely has very little of that substance present which, in the ordinary sense, as we understand it from the physiological standpoint, does carry sensation; nevertheless in enamel there is a certain amount of metabolic change occurring, and as a consequence of these metabolic changes which do occur in living enamel, that is to say, in the enamel of a tooth with a living pulp, there must be some sort of nerve control, otherwise nutrition of enamel is impossible; and I cannot believe that under ordinary conditions we would refer to living enamel as dead structure, as has been pointed out by some histologists.

From the standpoint of experimental pharmacology, at least, I am able to show you in my laboratory, the possibility of demonstrating that there are, under suitable conditions, metabolic changes occurring; minute as they are, nevertheless they do occur. However, these changes are so minute that they do not play any important part in this discussion on the subject of hypersensitive dentine. On the other hand, the dentine as such, ordinarily has no sensation. That is to say, sound dentine, healthy physiologically does not carry sensation in the sense of the word as we understand it, in speaking of sensation as the virtue of living tissue. Normal dentine will convey the sense of touch, the sense of heat, and the sense of cold. The transmission of these sensations, however, is a purely physical process, and not a physiological process by means of sensory or motor nerves. We know from the studies of such profound histologists as Mummery, Schaefer, Bodecker, Dependorf, Roemer, Walkoff, Gotlieb, Hopewell-Smith, and others, that the question of so-called innervation or nerve supply of dentine is an undecided factor. Some of the schools, especially those headed by Mummery, Schaefer, Bodecker and his followers, say that dentine contains nerve fibers; while, on the other hand, Hopewell-Smith, Walkoff and their followers maintain that dentine, on account of its anatomical nature, cannot and does not contain nerve fibers.

While in Berlin some years ago I made it a point to go over the slides of Bodecker very carefully. Incidentally I did the same thing in the laboratories of Gotlieb in Vienna, and at other places. Later on I had the pleasure of seeing Mummery's slides, who was over here at the dedication of the Evans Memorial Institute, and I was impressed with the idea that by very high magnification—2,500 diameters—that there were certain structures which in all probability resemble very closely nerve tissue. On the other hand, I am also impressed with the fact that ordinarily, knowing from clinical experience that normal dentine does not carry sensation, that these nerve fibers, if they are such, do not belong to the so-called sensory or motor type.

Again, we do not know that dentine in a tooth with a living pulp does not have a very pronounced metabolic interchange. An interchange of metabolism in a living cell can only be carried on in the presence of nerve tissue. This nerve tissue, however, belongs to the trophic nerve system, and has no bearing, in any shape or form, to the sensory or motor type. Hence, most likely, this point being overlooked, in due time our histologists will settle the question.

THE PATHOLOGICAL POINT OF VIEW.

NOW, THE NEXT important question is that we should have a clear understanding of what we mean by so-called hypersensitive dentine from the pathological point of view. All of you know—that goes without discussion—that you do meet patients who come to your office that have exposed dentine, which on the very slightest touch with an instrument, will call forth a paroxysm of pain, which is so pronounced in its character that one is at once confronted with the idea, how is it possible that these impulses of pain can be conveyed without the presence of nerves? We must have some sort of an explanation of this state of hypersensation in the solid mass of dentine. We can explain this hypersensation of dentine upon this basis, and it is a purely physical explanation, dentine in its histological structure, as you know, being composed, as I stated, of so much lime salts, so much water, and so much organic material, in the form of protoplasmic fibers. The number of fibers ordinarily referred to is about 25,000 to 30,000 to the area of a square millimeter. Imagine the area, so very minute, and that we should have upon this minute area so many of the tubes containing these fibers. These fibers are protoplasmic in their nature. That is to say, they are composed very largely of salt, of water and of albumen. Ordinarily these fibers carry on interchanges in the dentine, because we do know that in living dentine various metabolic changes occur, as, for instance, in the production of the so-called transparent zone. The transparent zone, as we know, is that zone in the ordinary performance of the destructive process of dental caries which shows an increased deposition of lime salts. This increased deposition of lime salts must come from an irritation carried to the odontoblasts, which are the depository of lime by some sort of an irritation. We also know that occasionally we have the production of secondary dentine as a sequence of external irritation, or the production of pulp stones as a sequence of external irritation. This external irritation must be by some means or another conveyed to the pulp, and it can only be by mechanical pressure upon the contents of these dentinal tubules.

Now, at any time that the normal enamel cap is destroyed, and the dentine with its minute fibers is exposed, these fibers become highly impregnated with water. This hyper-impregnation of water exercises a certain pressure upon the underlying filaments of the odontoblasts. Water, as such, as you know, cannot be compressed. We can compress gases; we can liquify air, nitrous oxid and carbon dioxid, but we cannot compress water. If we could compress water we would have no hydrostatic elevators, and so on. Ordinarily a column of water about a meter (or 39 inches) long, under the very highest pressure that we can obtain, can be compressed only the fraction of a millimeter. Now, when these dentinal fibers become impregnanted with or saturated with a superabundance of water, the slighest touch will at once convey this pressure to the other end of the tube, and the other end of the tube is the odontoblast fiber, and as a consequence the odontoblast fiber will carry this impression upon the filament of the nerve fiber which is present in the pulp, and hence the responsive sensation. If we have a normal tooth covered over with enamel, and we remove that enamel by cutting it away with the bur or stone, our patient will feel very little sensation, except the transmission of heat, which I have stated is a purely physical phenomenon. Now, if we coat over this tooth, say with nitrate of silver, or a hard varnish of some resinous substance, as, for instance, copal or sandarac, we will notice when our patient returns in twenty-four hours there is most likely no sensation present in the tooth.

On the other hand, if we have not done this coating with silver nitrate, or have not protected the surface with a layer of varnish, we have now a very pronounced hypersensation. This hypersensation is then due to the presence of water, causing those fibers to swell, and they, as a consequence, by the slightest amount of pressure will convey sensation to the dentine. At least, this is the explanation which will satisfactorily answer this conception of what we understand by the pathological anatomy of dentine.

TREATING HYPERSENSITIVE DENTINE—PHYSICAL METHODS.

NOW, THE LAST AND most important question of our discussion, after all, is the question of the treatment of this condition. For the treatment of hypersensitive dentine we have at our command two specific methods. We have, on one hand physical methods, and on the other hand we have the method of applying drugs. In regard to the physical methods at our command, primarily and most important is the use of very sharp instruments, applied with extreme dexterity and a steady hand. Second, we can overcome this hypersensitive condition of dentine by purely physical means, by means of dehydration. We can dehydrate a surface; and dehydration can be applied in various ways. We can use the hot-air blast as such, or we can use agents which are dehydrants, as, for instance, absolute alcohol, acetone, or any other substance which has a powerful affinity for water. Naturally all those substances will penetrate only a fraction of a millimeter; and then they have to be repeated over and over again.

Another physical means, which, however, in reality comes under the heading of the next subject, the application of drugs, nevertheless which partially leans over, laps over in the field of physical application, is the reducing of the temperature of the tooth by means of chemical agents. We can apply ordinary cold in the form of an ice bag, or in the form of such agents as will powerfully reduce the temperature, as, for instance, such low boiling chemical substances as ethyl chlorid, methyl chlorid, carbon dioxid or preparations thereof. However, those agents are very unsatisfactory. They reduce the temperature of the tooth by means of their physical conduction to such an extent as to create a partial anemia in the pulp. Whenever we create anemia in the tissue, as a consequence thereof we produce partial paralysis. Partial paralysis means inhibition of sensation. However, and most likely all of you have had some experience with these methods—they are incidentally productive of more or less severe pain in the beginning of their application. There is that very distinct and pronounced problem of shock from the cold, which is always most unsatisfactory; and consequently cold as such has very little bearing on the subject under discussion.

APPLICATION OF DRUGS—CAUSTICS.

THE NEXT IMPORTANT method that we have at our command is the application of drugs. We have two classes of drugs which are utilized for this purpose. One is the application of caustic drugs, and the other is the application of anesthetic drugs. Let us consider the first one, the application of caustic drugs.

When we apply a caustic we should have a clear understanding of what we mean by it. When we apply a caustic to a substance, that caustic will destroy organic or inorganic substances, immaterially whether it is living or dead tissue. It will produce microscopically recognizable changed forms; it will destroy it in such a way that it will perish, depending upon the nature of the tissue; it will cause coagulation, liquifaction or some other kind of destruction.

On the other hand, when we apply an anesthetic, the anesthetic does not produce any recognizable changes, but it interferes with the life of the cell to such an extent as to temporarily inhibit its function. Its paralyzation must be only temporary; it must not be permanent, because if it were premanent it would destroy the tissue.

Now, then, what drugs do we have that act as caustics? Any drug, indeed, that has what we call a caustic action can be applied for that purpose. We primarily use a drug that has a very powerful coagulating principle as its underlying base, as the various metallic salts. However, we only select a few, because some of them have different side actions which are not suitable for the purpose in view. For instance, no one would think of applying a concentrated solution of mercuric bichloride, which would cause coagulation, for there is that poisonous principle connected therewith, and incidentally also the discoloration. We would utilize an agent which produces a very quick coagulation of the surface without penetrating into the structure too deeply. And therefore we select usually silver nitrate. Silver nitrate will discolor the tooth black; however, only within a minute fraction of an inch. At that point it will limit itself by its own coagulation. Silver nitrate will produce a silver albumen, a hard substance which checks the further penetration of the silver into deeper structures.

On the other hand, we sometimes use zinc chlorid. Zine chlorid produces a colorless coagulum. However, that coagulum is not as solid, not as dense, not as rigid as the silver coagulum; and as a consequence the further penetration of zinc chlorid is not checked, and therefore in deep seated cavities there is danger of irritating and destroying the pulp by an application of an agent of this kind. Nevertheless, the two are the agents which are used more than any other of the metallic salts.

Then, we have, further, all the other so-called caustics of the sodium and potassium hydrate type. Sodium or potassium hydrate in pure form are rarely applied. We usually apply them mixed with an equal amount of crystals of phenol (carbolic acid) which is the old fashioned Robinson Remedy. This remedy is still widely used, and in slight cases of hypersensation it is undoubtedly of much benefit. There we have the combined effect of the potassium hydrate, on the one hand, and a phenol on the other. All phenol derivatives act as caustics. The liquified phenol will distinctly and pronouncedly coagulate albumen, and as a consequence, up to the depth of its coagulation, will destroy the albumen molecule, and as a consequence sensation will also be destroyed. All those agents, however, only act superficially. They must be repeated and repeated as we go on, and as a consequence they are rather unsatisfactory, except in slight cases of hypersensation.

APPLICATION OF ANESTHETICS.

WE COME NOW TO the second group of drugs, the anesthetics. Of the anesthetics we have two distinct kinds. We have on the one hand what is known as a general anesthetic; and on the other, what is known as the local anesthetic. A general anesthetic inhibits all sensation by its absorption in the circulation, and the other inhibits the organs of sensory activity in a circumscribed area of tissue which is deprived of sensation. It is but common sense that when we apply a general anesthetic, be it nitrous oxid or be it chloroform, or a combination thereof, all sensation in the body is inhibited, as long as the effect lasts, and as a consequence we can overcome the sensation of pain from the operation upon the hypersensitive dentine. But remember this, that when you apply an agent of that kind, of the general anesthetic type, it must be so deep as to inhibit all sensation. If you bring your patient only to that state which is generally called analgesia, you will never overcome hypersensitive dentine perfectly. Your patient will have a lessened amount of pain, but sufficient pain that he will be conscious of the effect of your cutting instrument.

Now, there is no objection to the use of a general anesthetic for that purpose, provided you are properly equipped in your office for doing that kind of work. There is no question at all that under suitable administration, nitrous oxid for the purpose of preparing sensitive cavities, can be applied with perfect success in the hands of those who are used to that kind of anesthetic.

On the other hand, we have the application of the local anesthetic. By that we mean a drug which inhibits sensation in a circumscribed area in the tissue. However, this refers only to soft tissue. When it comes to hard tissue, the application of a local anesthetic, as for instance, cocain, will not be of any effect whatsoever unless we convey that drug by means of certain physical procedures into the pulp *via* the dentine. As for instance, we can press by so-called pressure or contact anesthesia; by prolonged contact we can press some novocain solution into the albumen molecule; from there by osmosis or endosmosis it is conveyed to the entire Tomes' fiber, and it reaches finally the odontoblast layer and produces its definite results, as is known to you all in every day experience.

On the other hand, if you place this cocain merely superficially upon the dentine, it can remain there for hours without effect. It must be conveyed by means of osmosis through the entire dentine into the mass of the pulp to act upon the nerve fiber in the pulp to produce its true paralyzing effect. Furthermore, we can convey it to the dentine not merely by pressure or contact, but by electricity, by so-called cataphoresis. That also has been used very successfully in the hands of many: Others have condemned it for various reasons. We may take it for granted that most likely the cumbersomeness of the apparatus, the length of time required, the labor and special knowledge required to handle the apparatus, have brought this process into disuse. Nevertheless, there is a great deal of virtue in cataphoresis, and in the hands of those who apply it successfully today it is always a welcome remedy to overcome this particular difficulty.

Now, finally, we have one other method left, and that is the application of a local anesthetic directly or indirectly into the soft tissues surrounding that particular tooth and conveying it to the two nerve trunks which give sensation to the tooth; the trunk which enters at the foramen and gives sensation to the plup; and the other which enters into the peridental membrane, and gives sensation to the tissue.

How, then, can we overcome the difficulty of injecting into the structures without going through the bone, which necessarily must be done unless we apply what is known as contact anesthesia? If we naturally inhibit or block the nerve upon its exit from the foramen anywhere around the body we can cut out sensation at the terminal ends. Of course when we have a number of teeth in one single jaw we can block out the nerve which carries all the sensation to the various teeth, and as a consequence thereof we can readily and quickly paralyze the nerve tissue for the time being until sensation returns.

PERIDENTAL ANESTHESIA.

BUT WE HAVE A better method, and that method is what we are prone to term the peridental injection. If we can convey our anesthetic solution directly to the peridental membrane, we reach the nerve supply direct. And this is the only and perfect method at our command, which with the least injury to the tissues involved will give perfect results.

We should remember that the tooth is embedded in the alveolus surrounding each tooth. At the point where the apical ligament is located, there is a perforation of hundreds of little foramina around the tooth in the alveolar process, which allows the ready admission of fluid, more so if this fluid is conveyed under pressure. Now, if we inject in this region, only a very minute quantity of the ordinary amount of local anesthetic solution is necessary to bring about definite effects.

Before we enter into a detailed description of this method, we should have a clear understanding of what we mean when we speak about applying an injection of a local anesthetic in any part of the tissue. Remember when we speak of a local anesthetic we should have a combination of a number of factors at our command to insure perfect success. Otherwise it is a failure. You must have, first of all, a sterile field: your syringe and your needle must be sterile; second, you must have a solution of an anesthetic drug which is composed of powerful drugs arranged in such a way as to conform to certain physiologic and physical laws governing cell activity. You must, third, have selected a proper method of injection. You must have good sound judgment of the prevailing conditions. It would be folly to inject, for instance, a fluid of an anesthetic solution, or any other kind, into inflamed or diseased tissues. A combination of these factors is absolutely essential to produce definite results.

First, then, what anesthetic solution should be used? There is no need for me to enter at this moment into a discussion of the most valuable anesthetic. It is novocain. We would make a one and a half per cent. solution. The basis of the solution is a physiological salt solution one ounce, in which we place seven grains of novocain and bring it to a boil, and then we place it in a bottle. Then add to it as we need it at the time of our performance of the operation the necessary amount of adrenalin, *i. e.*, one drop to a cubic centimeter and three drops to about five cubic centimeters, and there we have about all we need for the ordinary condition. In the use of adrenalin you want to be very careful in adjusting the dose, because if you take too much adrenalin you will produce so powerful an anemia, lasting so long as to deprive the tissues for hours of their nourishment, and as a consequence sloughing will take place. One drop to one cubic centimeter is sufficient for the ordinary conditions. Now then, this solution is boiled ready for use at the time we wish to apply it.

In regard to the syringe, it should be a very powerful syringe of the so-called imperical type. Each practitioner should have a dropping bottle in which he can keep his salt solution. Each dropping bottle is gauged so as to give a specific number of drops to the cubic centimeter. Remember each dropping bottle differs as far as the outlet is concerned. We simply drop on an average, sixteen drops upon a tablet of novocain-adrenalin and bring it to the boiling point. We have our syringe sterile, ready washed out with alcohol and glycerine, or boil it occasionally. The needle must always be boiled, which goes without saying; and now we are ready for the injection.

STERILIZING THE OPERATIVE FIELD.

THE NEXT STEP IS how to sterilize the field under consideration. The sterilization of the field before injection in the mouth is absolutely essential. Much discussion has arisen in regard to the substance useful for the purpose. The simple and most convenient method of sterilization is to use a very weak solution of iodin, *i. e.*, a dilute tincture of iodin. One part of tincture of iodin mixed with two parts of acetone is a most satisfactory mixture. Acetone is a chemical which is an intermediate product in the making of chloroform. It is an agent which boils at a very low temperature, about 56° C., has a peculiar odor of chloroform; is soluble in water and alcohol, and on account of its low boiling point almost immediately evaporates; it is a very powerful dehydrant. When we use a combination of this kind we have very little discoloration, it only produces a very slight yellow tint. It does not interfere with the picture of anemia which we produce by our injection. Incidentally, it evaporates so quickly that it leaves a perfectly dry surface. The result of sterilization produced by this method is this, that it is not only a chemical sterilization but largely a mechanical one. Here you simply varnish the bacteria that are present at the surface by this quick evaporating agent combined with the iodin, and you have them glued to the surface; you have a dry surface through which now your needle may enter in perfect safety. There is no danger from it. And the quantity applied is so minute that no cauterization of the mucosa of the gum takes place, which is always the case with ordinary tincture of iodin. By means of a tooth pick wound with cotton, painting over the surface which has been washed with a salt solution, gives us now within a few moments a sterile field.

PERIDENTAL INJECTION.

WHAT ABOUT THE INJECTION? As I have said, we use almost exclusively the so-called peridental injection. This means that we introduce our liquid under force into the peridental membrane proper. First we must have access to it, and this we can readily gain by introducing the needle on the distal and again on the mesial side of the tooth. If you look at the jaw, and you look, for instance, direct say at the lower molar, you will find that the whole mass there is simply one large net work, and if you take your syringe and fill it with ink and introduce it into one of the holes, and give pressure to it, you will find that the whole mandible up to the place that the nerve pierces the mandibular canal is thoroughly saturated. And this holds good with every space between the teeth. Now, then, we thoroughly paint the solution around the tooth, as I have stated, and then introduce the needle into the circular ligament, or under the circular ligament. There has been certain objection raised against introducing the needle under the circular ligament, because the objection has been made that you cannot get rid of the deposits of food debris which is always present under the ligament, and as a consequence you may introduce some of the material into the peridental membrane. Well and good. If you don't want to introduce it into the peridental membrane, you can puncture the free margin of the gum by a short, sharp needle, introduce about a drop of the anesthetic solution so as to superficially anesthetize that tissue; and now force it on so as to reach the membrane proper. We should have some access to this peridental membrane, and this can be accomplished by wedging the teeth slightly apart by any of the mechanical separators placed between the teeth very lightly so as to give access to a number 26 or 27 needle. It should be a short, sharp needle, but the needle must be sterile. Now, we have filled our syringe, and we introduce this needle into the tissue. It isn't necessary to enter very deeply, possibly one or two millimeters, so that the opening of the needle is covered completely by the tissue, and now we exercise very slow continuous pressure. We do not need more than say about three to five drops. But if we bring this solution, this three to five drops, into the peridental membrane, we are absolutely sure to reach the nerve supply of that tooth direct, because the branch of the trunk that supplies the tooth incidentally also supplies the pulp, and as a consequence direct anesthesia is always the result. We take two injections, one distally and one mesially. If the tooth stands alone, it has a certain amount of movement, and as a consequence thereof, it is very simple to inject. If the tooth stands in a row and is very tight, then we have to slightly wedge it apart by any of the usual means as we have outlined.

Now, then, we inject on either side as soon as we are ready with our injection, which on an average should not take more than five minutes. We are now ready to adjust the rubber dam; and when you come to cut your tooth you will find that that tooth has absolutely lost all sensation.

ELECTRICAL TEST OF PATIENT'S RESISTANCE.

WE GO TO WORK in an experimental way in our institution in the following manner. I have an electrical apparatus, and I measure the resistance of the patient on that tooth. My rheostat will tell me in figures—not so many inches of sensitiveness—but it will give upon an attached board divided into ten parts—the resistance of the patient. The negative pole is in the hands of the patient and the positive pole carried by the dentist. A few fibers of cotton are wrapped around the end, dipped in water, and placed against the tooth, the current is turned on, and now by increasing the current we come to a point where the patient responds with sensation. We measure, then, the resistance of the patient to pain in that way.

After the proper injection the tooth is completely paralyzed, and it will remain paralyzed from thirty to forty-five minutes to an hour. In about an hour's time sensation will slowly return, and we can measure that again with our apparatus.

POSSIBLE DANGERS.

YOU MAY SAY, what danger arises therefrom? Is there any damage to the pulp? There is no danger. There has never come to my knowledge a case where the pulp has died from strangulation or otherwise from the use of this type of injection. Sensation will always return in due time exactly in the same way it is present in any other tooth. The patient will smile and be happy in the thought that all this painful condition has been overcome. You prepare your cavity, insert your filling material, and you usually have time to complete the filling before sensation returns. The only danger lies in the fact that after you have anesthetized that tooth completely you may cut too much of the dentine and endanger the pulp. That, of course, you should not do.

DESENSITIZING PREPARATIONS.

NOW, A WORD AS to the so-called various copyrighted preparations that are used for desensitizing purposes. One of the oldest drugs that has been very largely advocated and used by the profession in bygone days is arsenic. I have heard in my early days of the study of dentistry out west some men advocate a mixture of arsenic and oil of cloves, wiping out a cavity therewith and letting the patient go. On his return in twenty-four hours, that cavity is desensitized; so is the pulp desensitized, and it remains desensitized. Lately formalin has been used. Formalin and formaldehyde have been stated to be revolutionizers in the treatment of hypersensitive dentine. They worked perfectly. The pulp became desensitized, and it remained so. In most cases it remained so perfectly desensitized that now-a-days this desensitizing paste is used by many practitioners for the purpose of devitalizing pulps in children. Of the other desensitizing materials that are used for the purpose, as, for instance, the so-called Dentine Anestheticum as produced in Norway, it is also found that the pulps will die. Graham has shown that: First, the albumen molecule is, comparatively speaking, very large; and, second, living protoplasm possesses that vital force which is resistant to any foreign substance. As a consequence thereof we have had very great difficulty in studying living tissues and it is only within the last few years that substances have been procured which stain certain specific living tissues somewhat in the same sense that salvarsan will act upon the organs causing syphilis. But ordinarily the staining of the living tissue is one of the greatest difficulties that we find. On the other hand, the very moment that a tissue is dead we can stain it in any shape or form that we want.

Some years ago a drug was brought out under the name of nervocidine. It was claimed to be an alkaloid of an Indian plant, Gasu-Basu, and which possesses the faculty of desensitizing or of paralyzing nerve tissue. And it did. The pulp paralyzation was so complete that sensation never returned. And as a consequence it could not be used for such purposes.

Remember that a drug which answers all purposes equally well as far as reducing hypersensation of dentine is concerned must, first, be a drug which produces this effect in a few minutes; second, it must not produce pain during its application; third, it must not injure the pulp; and, fourth, it must not discolor the dentine. Any of these qualities missing makes it an undesirable agent. And as a consequence the most satisfactory method and the one that gives you the best results, and the one that will always give you not alone satisfaction, as far as the patient is concerned, but your own self, is a thorough mastering of the methods of local anesthesia, especially in the form of the so-called peridental injection.

AT VARIOUS TIMES high pressure anesthesia has been advocated for cavity preparations and Raymond E. Ingalls, writing in the Dental Cosmos, 1917, revives interest in the procedure and presents a new compressed air obtunder for carrying out the technic. In introducing his subject Ingalls sounds the following warning:

The hand writing is on the wall; the admonition is to prepare, for the public is beginning to demand less pain in the dental chair. The urgency, the wisdom, the necessity for the *slacker* to adopt one or several of the means at hand for the prevention of pain is rapidly becoming more and more acute. "Man must progress or he is certain to retrogress," is a simple statement of undeniable truth particularly applicable to members of the dental profession. The vulnerable and absorbing point with the person in need of dental service is always the dread of being hurt. The dentist is well aware of this fact, even more so than the public. Glib and voluminous as has been the sum total of what has been spoken and written on the subject, yet only a mere residue of doubtful generalities is probably left in the mind of the busy practitioner in pursuit of information. This may be a plausible excuse in many instances for the lack of interest on the subject; however, the impressive statement of the Hon. George A. Post, the president of the Railway Business Association, New York, may be *apropos* of the situation: "We are not acquainted with the coward who could venture nothing, the penurious who would spend nothing, the indolent who would do nothing, the critic who carps at everything that does not originate with him, and the visionary who bawls loudly for the instant approval of anything he thinks he thinks."

The compressed-air obtunder or any other of the present types of high-pressure syringes will never become popular with the average practitioner; the technic is the restraining factor. Not that the rank and file do not possess the mental faculty for mastering the technic, but they will not do so.

VARIOUS METHODS SHOULD BE STUDIED.

OF ALL THE appliances and methods for the relief of pain in dental operations, none are perfect or nearly so, but each possesses certain merits not found in others. For this reason the operator should understand more than one method. Before giving the advantages of the high-pressure syringe method, certain statements on other methods by men of national repute will be given.

NITROUS OXID ANALGESIA.

THE FOLLOWING quotation, taken from recent dental literature, was made by a nitrous oxid analgesia enthusiast: "The diet preparatory for nitrous oxid analgesia should be the same as for anesthesia, *viz.*, a fasting condition for three hours. * * * The patient most sure to bring failure is the one who is accustomed to the use of strong drink as a matter of habit. * * * Patients addicted to the use of drugs, either as an uncontrollable habit or as a medical treatment, will be found to be unreliable. * * * Patients who make no effort to cooperate with the dentist, due to inability or refusal to exert will-power, will be found unsatisfactory; suggestion in these cases avails us nothing, for the reason that the patient will not dwell upon our statements."

CONDUCTIVE ANESTHESIA.

SPEAKING OF the pterygo-mandibular injection in conductive anesthesia, one writer states, "Anesthesia occurs in from fifteen to twenty minutes." Under the heading of "After-effects," the same author informs us that—"There are swellings which disappear without treatment and possibly pain from the above sources or from infection during or after the operation."

Referring to intra-osseous, infiltration, and conductive anesthesia, another dentist comments on certain physiological symptoms. This writer's remarks are similar to those made by others: "Seventeen showed decided symptoms of intoxication to a greater or less degree. * * * Only two lapsed into a state of coma."

With the numerous reports of satisfactory results of pain-saving procedures other than the high-pressure syringe method, any attempt to detract from their excellence would only bring deserved ridicule; there is no intention to depreciate their worth—and I may say here that I do not rely wholly on compressed-air obtunder. Preliminary preparation, such as diet and loosening of tight clothing, are not necessary in high-pressure anesthesia. Alcoholics and drug-addicts respond to treatment as quickly and as readily as abstainers. A reassuring talk to gain the patients' confidence so that they will make an effort to assist the operator by a concentration of will-power is entirely unnecessary. It is only necessary to display the obtunder and inform them that the flat needle-point will be held against the tooth until a sufficient amount of the anesthetic is absorbed to enable the operator to perform the work in hand painlessly. The operator can assure the patient that there will be no pain at any time, either in using the obtunder, in operating, or following the treatment. There is no waiting for the anesthetic to be absorbed, as in conductive anesthesia, and excavating may begin immediately after using the obtunder in from thirty seconds to two minutes. As to physiological symptoms and after-effects, there are none.

Fig. 1.

The Syringe.

DESCRIPTION OF THE SYRINGE.

THE COMPRESSED-AIR obtunder provides a positive means of furnishing a consistent pressure without special effort on the part of the operator. The working parts of this instrument are made of correct mathematical size so that, with a source of air-pressure of forty pounds, a pressure of three thousands pounds to the square inch can be produced in the liquid-chamber of the syringe. A cross section of the opening in the needle-point, which is of No. 22 gauge, measures only an infinitesimal fraction of a square inch, therefore very little effort is required to hold the obtunder against the tooth, merely the weight of the instrument being almost sufficient to give close contact.

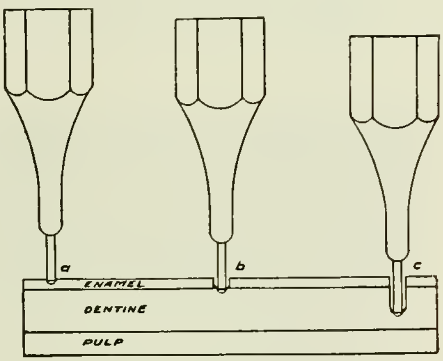
PREPARING THE POINT OF INJECTION.

FIGURE 2 REPRESENTS the three stages in preparing the pit and desensitizing the dentine. A sharp No. 1 round bur is selected and the enamel is cut into about one-half or a little more of the depth of the bur's head, forming a miniature hemisphere. This initial pit is best started by holding the bur with its long axis parallel to the surface of the tooth rather than at right angles, as the bur cuts much faster when held in this position. The rubber dam is unnecessary unless otherwise needed for the work in hand. Having previously drawn the anesthetic into the obtunder and warmed it to about body temperature by holding the liquid-chamber over a flame, grasp the knurled barrel in the right hand (Fig. 1) and use the thumb to manipulate the cut-off. The needlepoint is then placed in the pit (Fig. 2, *a*), and gentle pressure is exerted with the hand, using a slightly rotating motion. The air is allowed to enter the obtunder slowly. When the finger-lift comes to a stop, it indicates that the tooth is receiving full pressure. The instrument is held in this position for precisely twenty seconds—not guessing at the time. The seconds should either be counted or timed with a timepiece. The injection will then be driven between the enamel rods and into the dentine. A slight leak of the anesthetic around the needle-point or the escape of a small amount of air from the air-chamber will not retard the effectiveness of the anesthetic.

LIQUID-TIGHT CONTACT NECESSARY.

THE DISCOURAGING factor to the beginner in high-pressure anesthesia is the inability to always have the contact between the tooth and the needle-point liquid-tight, but this readily becomes the simplest part of the procedure after some practice. If a leak occurs it may be due to one of several causes; either the pit is imperfectly formed, or the needle-point is worn, or its margins broken so that it is not perfectly round. Or perhaps the engine handpiece was not held steadily, or a worn bur was used, in which case it is impossible to form a pit absolutely symmetrical in outline. The flat end of the needle-point should form a perfect right angle with the outer cylindrical surface of the pit—the needle-point must be square, and not rounded. This may be secured by dressing down the point with a cuttle-fish disk. Indeed, this little precaution had best be taken after every three or four cases. The operator may at times resort to the

Fig. 2.



use of a few cotton fibres between the needle and pit, but this is seldom necessary.

The next step is to enlarge the pit with a No. 3 round bur, and deepen it down to the dentine. If the enamel is thin, as it is near the gum margin, do not change burs. With the No. 1 bur make a depression in the enlarged pit to receive the needle (Fig. 2, *b*). The obtunder is now applied for fifteen seconds. This injection is largely in the nature of a precautionary measure, to make sure that there will be no pain when the dentine is penetrated farther with the bur. The pit is finally deepened to two-thirds of the distance to the pulp, and again countersunk with the small bur (Fig. 2, *c*).

APPLYING THE ANESTHETIC.

THE TIME ALLOWANCE for the use of the obtunder at this stage depends principally on the tooth being treated, although the age of the patient should be considered—the older the patient the longer the time required to desensitize the tooth. Of course in youth the pulp is large and the dentinal tubules more adapted to receiving the anesthetic, while in older patients there are deposits of dentine, perhaps *curly* dentine, making anesthesia more difficult, and demanding more time to force the anesthetic into the pulp. For a person, say, thirty years of age, forty-five seconds should be allowed for lower incisors and upper laterals; one minute for upper central incisors, canines, lower bicuspids, and upper second bicuspids; one and one-half minutes for upper first bicuspids, and two minutes for molars. The lengths of time given should be doubled if the pulp is to be extirpated. used. If through carelessness an overdose of the anesthetic is given, causing a strangulation from which the pulp does not recover, death of the pulp may be the result. But this contingency is as remote with the careful operator as that of the physician causing the death of a patient by an overdose of a drug. There is never any danger of having injected too much of the anesthetic if the dentine is still sensitive. This condition merely indicates the lack of a sufficient amount of the anesthetic.

LOCATION OF THE POINT OF INJECTION.

THE PIT SHOULD be included in the finished cavity, but should not be disturbed until the balance of the cavity is prepared, as there may be some sensitiveness remaining that would necessitate further use of the obtunder. As the enamel walls become thinner toward the cementum, it is easier to make the pit near the gingival line. The best results are obtained by making the pit in healthy dentine near the injunction with the affected area. The point of injection should be made at the most accessible point in the cervical portion of the tooth when preparing a tooth for a crown abutment. If a pulp extirpation is desired in the case of a badly decayed molar in which the pulp is almost exposed, the most accessible point at which to use the obtunder is possibly within the cavity itself, removing the soft decay about a millimeter from a pulp cornu, and making the pit at that point.

Sometimes the cervical point of injection is not practicable. In such a case make a pit over a cornu of the pulp on the morsal surface. Start the bur next to but not in the fissure through which the cavity is to be extended, directing the


Fig. 3—A and B.

Should there be any escape of the solution from around the needle-point in the final application of the instrument, it may be assumed that the pit is irregular in outline. It is a simple matter to straighten the walls with a spear-point, dentate, or fissure bur.

ANESTHETICS USED.

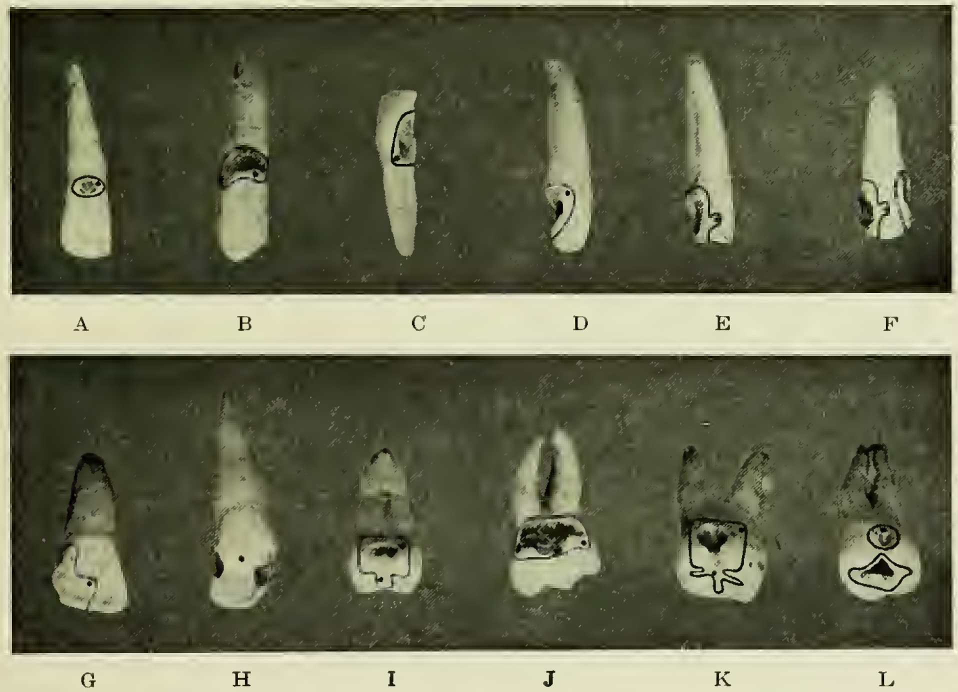
AS SUCH A small amount of the anesthetic actually enters the pulp—one-sixth of a drop is the estimate—a two per cent. solution of cocain is perfectly safe. However, should the operator have an aversion to cocain, the novocain-suprarenin tablets *E*, containing novocain 0.02 gram and suprarenin 0.00005 gram in a two per cent. aqueous or normal salt solution, may be bur toward the cornu after reaching the dentine. The pit in this case also should be included in the finished cavity. The dots on the teeth in Fig. 3, A and B, indicate the different points at which the injection can best be made.

The simplest cavity and the easiest to obtund is the gingival cavity, notwithstanding the fact that such cavities are the most painful to prepare if the tooth is not desensitized. This type is shown in Fig. 4, A, B. In the upper lateral, A, The lower right central, C, may best be obtunded at the labio-mesio-gingival angle.

SINGLE INJECTIONS FOR TWO CAVITIES.

WHENEVER AN OCCLUSAL and a labial cavity occur in the same tooth, D, the injection for the labial cavity will suffice for both. It is always necessary to force the anesthetic into the pulp for any cavity unless the cavity is extremely small—less than pinhead size, therefore

Fig. 4.



the affected area probably would not extend to the gum. This would allow sufficient space for the injection to be made at a point between the cavity and the gum margin. As the enamel is quite thin at this point, precaution should be taken not to go too deep with the No. 1 bur before the first injection, as the dentine is readily reached and pain would be caused. In the case of the upper canine, B, the decay would generally extend beneath the free margin of the gum, and it would be necessary to make the pit to the mesial, distal, or morsal of the carious portion.

at least the crown of the tooth should be anesthetized, and any number of cavities in it may be prepared or the tooth prepared for crown painlessly. It is usually most convenient to use the obtunder directly over the pulp on the lingual surface when it is deemed advisable to prepare an L cavity or make a lingual retention, E, F. Where there is a large cavity and exposure of the pulp, high-pressure anesthesia is not indicated, and the ordinary hand-pressure anesthesia method should be employed. Considerable cutting is usually necessary to prepare a cavity for a filling or an inlay where a corner of a crown is broken off, G, particularly if the morsal surface is well worn and the bit is short. A very secure anchorage is necessary in such a case, for the reason that in these cases much stress will be brought to bear on the filling in the mastication of food. Much cutting means much pain, but the pain is easily eliminated by the use of the high-pressure syringe.

In a badly disintegrated tooth, H, either a crown or filling may be indicated. If the pulp is found vital—and always ascertain whether or not it is devitalized—and a crown is indicated, the point selected for anesthetizing should be on the labial surface; but if fillings are indicated, the pit should be at the mesio-labio-gingival angle, the disto-labio-gingival angle, or on the lingual surface over the cingulum. In the case of a bicuspid or molar having an approximo-occlusal cavity, I, K, the needle is best inserted close to the gingival line adjacent to the infected area. If this point be difficult to reach, the morsal surface may be chosen. There is no unnecessary waste of tooth structure if Black's extension for prevention principles are conscientiously followed.

Lastly, in the case of a carious molar, in which there is both a morsal and a buccal cavity, L, it is another case of "two birds with one stone," and one injection on the buccal surface as indicated is sufficient to desensitize the tooth for the preparation of both cavities.

WHATEVER HIS NATURAL ENDOWMENTS, THE ANESTHETIST IS NOT BORN, LIKE THE POET, BUT MUST GO THROUGH A LONG AND ARDUOUS TRAINING. THE MANY COMPLICATIONS THAT MAY ARISE DURING ADMINISTRATION ARE NOT OF FREQUENT OCCURRENCE, HENCE IN AN AVERAGE PRACTICE SOME THOUSANDS OF ADMINISTRATIONS MUST BE MADE BEFORE THE ANESTHETIST HAS SEEN THEM SUFFICIENTLY OFTEN TO BE FAMILIAR EVEN WITH THE MORE COMMON. BOOKS OF COURSE ARE USEFUL; THEY TEACH THE BEGINNER THE RULES OF THE GAME, BUT PRACTICE IS THE ONLY THING THAT MAKES HIS PLAY PERFECT. INDIVIDUALS VARY, BUT ON AN AVERAGE IT TAKES QUITE FIVE YEARS TO OBTAIN A THOROUGH MASTERY OF THE ESSENTIALS AND ANOTHER FIVE TO ACQUIRE ALL THE REFINEMENTS OF THE SPECIALTY OF ANESTHESIA AND THE ABILITY TO DEAL WITH EVERY EMERGENCY WITH COOL CONFIDENCE AND PROMPTITUDE. EVERY ANESTHETIST IS THE BETTER FOR HAVING SEEN SOMETHING OF GENERAL PRACTICE. IN ADDITION TO THE MEDICAL KNOWLEDGE ACQUIRED IT GIVES AN INSIGHT INTO HUMAN NATURE WHICH IS INVALUABLE IN DEALING WITH ALL SORTS AND CONDITIONS OF PATIENTS DURING THE PRELIMINARIES OF INDUCTION.

—G. A. H. Barton.

THE TECHNIC OF INTRA- AND EXTRA-ORAL NERVE BLOCKING FOR ORAL SURGERY AND DENTISTRY . GENERAL CONSIDERATIONS . ADVANTAGES . THE WAITING PERIOD . A THOROUGH KNOWLEDGE OF THE ANATOMY . DISSECTED WET ANATOMICAL SPECIMENS . STRICT ADHERENCE TO ASEPSIS . PRELIMINARY AGENTS . MANDIBULAR-LINGUAL ANESTHESIA . INTRA-ORAL METHODS OF BLOCKING THE INFERIOR DENTAL AND LINGUAL NERVES, THE SECOND DIVISION OF THE FIFTH . EXTRA-ORAL BLOCKING FOR THE INFERIOR AND THE SUPERIOR MAXILLARY NERVES . THE INFRAORBITAL AND ANTERIOR SUPERIOR ALVELOAR NERVES . NERVE BLOCKING ANESTHESIA FOR TONSILLECTOMY . THE ANESTHETIZING SOLUTION . CAUSES OF FAILURE AND UNTOWARD RESULTS IN CONDUCTIVE ANESTHESIA . REQUIREMENTS OF AN IDEAL LOCAL ANESTHETIC . NOVOCAIN-SUPRARENIN SOLUTIONS . DISTILLED WATER . TOXICITY . INSTRUMENTARIUM . METHODS . ANESTHESIA OF THE UPPER BICUSPIDS . PAIN DUE TO INJECTION . INFILTRATION OF INFECTED AREAS . FAULTY METHODS OF OPERATION . OTHER UNTOWARD RESULTS . CONCLUSIONS . THE TEACHING OF CONDUCTIVE ANESTHESIA . NECESSITY OF PRACTICAL COURSES FOR SMALL GROUPS OF STUDENTS WITH INDIVIDUAL INSTRUCTION AND OF PRELIMINARY STUDY OF THE ANATOMY OF THE PARTS INVOLVED . DISCUSSION OF ASEPSIS, SOLUTIONS AND INSTRUMENTS . MANAGEMENT OF PATIENTS . TEACHING OF PALPATION, INJECTION ET CETERA ON THE PATIENT . OTHER ADJUVANTS IN DEMONSTRATING AT THE CHAIR . LACK OF SUCCESS DUE ONLY TO NEGLECT OF THE MENTIONED PRINCIPLES FOR INSTRUCTION .

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SPEAKING BEFORE The Odontological Society of Chicago, March 6, 1918, Arthur E. Smith, reviewed in extended detail the subject of anesthesia in dentistry. He devoted the greater part of his address to a consideration of the developments in nerve blocking that have made it one of the most useful forms of anesthesia for dentistry and oral surgery. Smith has spent much time in the anatomical laboratory working out the basis for exceptional advice regarding the technical details of various nerve blockings for different injections. The most interesting phases of his technic are herewith republished from the Dental Review, June, 1918:

NERVE BLOCKING FOR OPERATIONS IN ORAL SURGERY.

THE DEVELOPMENT OF local anesthesia has been of great magnitude during the past few years and has found a place in modern surgery. This important branch of anesthesia has been developed to such an extent that it has not only attracted the attention of the oral surgeon and dental practitioner, but the general surgeon as well, and we are now able to obtain results heretofore unattainable through the medium of general anesthesia. It is a well-known fact that many times the oral surgeon is handicapped while operating for various pathological conditions on the jaws or within the oral cavity when a general anesthetic is employed.

The head and neck offer an available field for operations under nerve blocking. This is especially true of operations involving the face and jaws from the very fact of the constant location and susceptibility of the nerve trunks supplying these parts. The modern trend has been in the direction of blocking the deep nerve trunks and this technic has made possible many major operations which were heretofore performed only under a general anesthetic. *It goes without saying that nerve blocking should only be employed in cases where it is possible to completely block the operated area and render it insensible to pain.*

Nerve blocking is technical and demands skillful technic in its employment in order to attain satisfactory results for both the operator and the patient. Considerable skill is required in making the deep nerve-blocking injections, and every one must expect failure at the beginning. The operator should blame failure to the technic used and should search diligently for the cause of failure to render the parts insensible to pain. The trained anesthetist can make a most valuable use of psycho-therapy in addition to his general anesthetic, and this is of exceptional value to the operator employing local anesthesia in its different branches. The imperfection of the technic often leads the operator to persuade his patient and he himself labors under the delusion that the patient experienced no pain. When the operation is upon a patient who is hysterical and of nervous temperament, and anticipation and fear of pain are added to the adverse conditions which go to make up the failure, the patient may actually cry out and manifest a high degree of excitement during the operation and afterward tell the operator that she felt no pain. This type of patient should never be given a local anesthetic, but a general anesthetic should be employed because the dread of the operation and the fear of being hurt is as wearing upon the nervous system as is the actual pain. In every case requiring an anesthetic we should use our best judgment in deciding which to use:—a local or a general anesthetic. The nature of the operation and the physical condition of the patient should both be taken into consideration in the selection of the anesthetic. The anesthetist must not be hasty in his decision.

Modern surgeons have recognized the value of local anesthesia, and at the present time extensive operations are performed with great advantage with its scientific employment. Its field has been greatly aided by the vast amount of research work accomplished within late years. Much credit is due to those who have contributed to this important branch of anesthesia, especially Corning, Braun, Crile on anoci-association, Fischer, Shultz, Hertzler, Lyon, Puterbaugh, Allen, Thoma, Blum and Silverman. Extensive major operations can be performed under nerve-blocking and this field has been greatly broadened by the knowledge that the viscera is innervated by purely visceral nerves which are insensitive and sensation exists only in those nerves which receive branches from the somatic nerves. In late years it has been found that the viscera can be cut, sutured and handled without any severe pain if they are not pulled upon, which, of course, leads to the advancement of modern surgery and anesthesia, hence the value of anoci-association. One of the greatest advantages of operating under nerve-blocking is the freedom from anesthetic accident, blood changes and anesthetic discomforts. The disadvantage of local anesthesia is the patient's knowledge of what is taking place. This may be overcome in nearly every case if the anesthetist is tactful, masterful and assuring. Many surgeons are employing local anesthesia with satisfaction for the following operations: Appendicitis, hernia, empyema, gastrostomy, tracheotomy, goiter, rib resection, inguinal colostomy, various amputations, varicocele, hydrocele, circumcision, ligation of arteries, removal of subcutaneous tumors, and other general surgical operations.

ADVANTAGES.

THE ADVANTAGES OF nerve-blocking anesthesia for oral and dental surgery operations are many but the following are probably the most important: *First*, the duration of the anesthesia may be changed according to the various amounts of the vasoconstricting agent. The long duration of anesthesia is of great value to the operator for the removal of impacted third molars, draining the antrum, root amputation, removal of tumors, removal of cysts, resection of the jaw, curettement of necrosed bone, plastic operations, removal of tonsils, and many other operations which come under the observation of the oral surgeon.

Second, long duration of anesthesia permits the operator to take his time with the operation, which gives him the opportunity to employ all his skill while operating.

Third, large or small areas may be anesthetized, depending upon the nerve or nerve branches to be blocked.

Fourth, anesthesia is secured of infected or inflamed areas by blocking the nerve branch in healthy tissue at a distant point from the operative field.

Fifth, nerve-blocking injections, when skillfully made, are without pain because the needle is inserted into the mucous membrane and loose connective tissue.

Sixth, one or two insertions of the needle will block an operative field, depending upon the nature of the operation and the area to be blocked.

Seventh, cooperation of the patient. It is well known that this is of material advantage to the operator because he can operate with ease and complete the operation with a minimum amount of laceration and without the inspiration of blood and mucus.

METHODS.

LOCAL ANESTHESIA is divided into first, nerve-blocking anesthesia; second, terminal or peripheral anesthesia. The terminal or peripheral method is divided into several subdivisions, which are given in the order of their importance in the writer's opinion:

First, Intra-osseous method; Second. Infiltration method; Third, Peridental method; Fourth, Pressure anesthesia. For the terminal or peripheral method, or any of its subdivisions anesthesia is brought about by inhibiting the function of the terminal or peripheral nerves in a circumscribed area. Nerve-blocking, or in other words, conduction anesthesia is accomplished by injecting the anesthetizing solution near the nerve tissue at some point between the operative field and the brain. The nerve-blocking method is divided into the extra-oral and intra-oral, second into perineural and endoneural methods.

For the perineural method of nerve-blocking the solution is injected into the neighborhood of the nerve trunk supplying the operative field, and the solution reaches the nerve by diffusion, while for the endoneural method the needle point is inserted into the nerve direct and the solution injected. The latter method is of little or no value in the production of anesthesia for oral surgery and is used to a small extent. We are aware of the fact that the finest branches of the terminal nerves are covered only by a very thin sheath and this sheath increases in thickness as it passes toward the brain.

THE WAITING PERIODS.

IT IS EVIDENT that the smaller the nerve the more readily an anesthetizing solution will reach the fibers making up the nerve sheath, thus blocking painful impulses. Now, it can be said that the larger the nerve trunk and the thicker the nerve sheath that a longer period of time must be allowed for the anesthetizing solution to produce complete anesthesia of that particular nerve trunk. *Some operators overlook this important phase of technic, in not allowing sufficient time to elapse between the time of injection and the time for operation.* For the terminal anesthesia method the solution is injected into a circumscribed area and the solution comes in contact with the fine terminal endings and their sensory end organs. The area of operation is infiltrated and has its drawbacks in many operations. The first advocate of the deep injections was the American Corning, who introduced it to the profession in 1887. Following this Braun called the method conduction anesthesia. It appears to the writer that the term nerve-blocking is superior to the term conduction. The time required to wait for anesthesia following the injection into the nerve trunks depends upon these factors:

1. Diameter of the nerve trunk and thickness of its nerve sheath.

2. Percentage and amount of anesthetizing solution injected.

3. The skill of the operator in depositing the solution in the right location. *The operator must bear in mind the required time to wait for anesthesia and not be too hasty in beginning the operation before complete anesthesia has intervened. It might be stated here in a general way that the time to wait following the injections of solution into the various nerve trunks supplying the operative field of the oral surgeon, is from one-half minute to fifteen minutes, depending upon the size of the nerve or nerve trunks which have been blocked.*

The specialist or practitioner taking up the various forms of local anesthesia and more especially the deep nerve injections must appreciate that it involves many important details; and that each step is a well-defined and separate feature; and that neglect or over-sight in any of these details may result in an unsatisfactory anesthesia. The following rules should be strictly adhered to to obtain satisfactory results.

First, a thorough knowledge of the anatomical parts. Second. strict adherence to asepsis. Third, carefully selected equipment. Fourth, the technic must be mastered. Fifth, judicious selection of the correct methods to be employed in each individual case. Sixth, diagnosis of any and all existing conditions. Seventh, the use of an isotonic anesthetic solution composed of ingredients corresponding to the physiological laws of osmotic pressure and functions of the living cell.

A THOROUGH KNOWLEDGE OF THE ANATOMY NECESSARY.

IT IS IMPOSSIBLE in this short paper to discuss the anatomy that is so necessary for the operator to know, but I refer him to any standard text-book and the dissecting room. I wish to lay special stress upon the absolute importance of a thorough knowledge of all the anatomical parts, especially the osteology, the nerve branches and their relationship to others, together with their communicating branches. A thorough knowledge of the anatomy and anatomic relations is absolutely necessary to give the nerve-blocking injections; otherwise how can you obtain the desired results? You will only subject the patient to an experimental procedure.

DISSECTED WET ANATOMICAL SPECIMENS.

I AM A FIRM BELIEVER in dissected wet anatomical specimens from the very fact that they are instructive. The student and post-graduate can obtain more practical knowledge from a few hours' conscientious studying of carefully prepared specimens or in the preparation of the specimens than by spending days perusing books on anatomy. It has been my pleasure to prepare a large number of specimens, which have proved of immeasurable value in the execution of my work and to members of the profession who have studied them. These specimens were carefully embalmed and prepared before sectioning at various levels. They show the different nerve trunks and branches, ganglia, arteries and veins, and bony landmarks. They show all the anatomic landmarks in their relationship to each other, which come under the operative field of the oral surgeon as well as the eye, ear, nose and throat specialist. Time will not permit me to go into the dissection of these specimens, but I desire to refer to one in a very concise manner. The head was sectioned through the median line, and an incision made from the external angular process of the frontal bone to a point 3 cm. above the pterion, then to a point anterior to the antitragus—extending downward to a point midway between the sigmoid notch and the angle of the mandible. After making this incision a flap of skin and muscle was carefully separated from the periosteum over portions of the following bones; temporal, parietal, sphenoid, maxillary, malar and ramus of the mandible. Portions of these bones were trephined away and a portion of the temporal and frontal lobes of the brain removed, exposing the following structures: Gasserian ganglion, first, second and third divisions of the fifth nerve, the posterior, middle and anterior superior alveolar nerves, Meckel's ganglion, posterior, middle, anterior, and naso-palatine, inferior dental and lingual nerves, internal maxillary artery and several of its branches. The superficial origin of the fifth cranial nerve is at the side of the pons varolii and is shown connecting with the Gasserian ganglion. The fifth nerve and all its branches are carefully exposed to their termination. The various foramina, such as the infra-orbital, mental, anterior palatine, posterior palatine, posterior superior alveolar, inferior dental, show the nerve trunks as they pass through them. It is very instructive for the operator taking up this work to practive placing the needle in the various regions for making injections. In this way he will become familiar with the depth and direction of the needle for blocking the nerve trunks. Many hours are required to properly prepare specimens but one is amply repaid by the careful dissection required to properly prepare them.

STRICT ADHERENCE TO ASEPSIS.

SUCCESSFUL SURGERY is clean surgery. Antisepsis is the destroying of bacteria or septic conditions in wounds or tissues by the use of some germicidal agent. Asepsis is the practice of thoroughness in a wound already sterile. Sepsis is a condition where specific or infective bacteria exist, and where inflammation in some degree follows. It is needless to say that absolute adherence to asepsis must be followed in all forms of local anesthetic injections, but more especially the blocking of the deep nerve trunks. We are aware that it is almost impossible to render the mucous membrane absolutely sterile by reason of the delicacy thereof, but we may have an almost if not quite sterile area for the insertion of the needle. Many different forms of micro-organisms are present in the mouth and it follows that we must be very careful in considering any and all existing pathological conditions.

Any operation coming within the bounds of the oral or dental surgeon should be performed under and within the utmost regard for the principles of asepsis. The puncturing of the mucous membrane for the insertion of the needle prior to making an injection seems of little importance to some practitioners, and, while it is true that the tissue tolerates numerous punctures, yet it is inevitable that the practitioner who disregards asepsis will have his regrets in the future. The deep nerve-blocking injection is different from the other forms of local anesthesia because the needle puncture is made at a point some distance from the field of operation and can in most cases be made in healthy tissue. This holds true in practically all of the dental operations. In such cases as come under operative dentistry the oral cavity is more or less free from pus and nerve-blocking injections may be made by the intra-oral method. However, if the oral cavity is infected and pus is present, indicating infection, or if the operation comes under the head of surgery, the needle should be inserted into the tissue with caution. In a large number of cases it is possible to block a nerve by the extra-oral method either in the case of fractures of superior or inferior maxillary bones or for the removal of impacted third molars, curetting of the antrum, or resection of the jaw, coupled with infection producing partial or complete closure.

If the intra-oral method is employed the tissues within the oral cavity should be sprayed with an antiseptic solution. After this, the mucous membrane in the range of the puncture should be thoroughly dried and this is done best by using several pieces of sterile gauze held with artery forceps. Then apply a germicidal solution. I have tried many different solutions for this purpose, but have found none as efficient as equal parts of tincture of iodin and ethyl-alcohol, which gives 3½ per cent. solution of iodin and minimizes the chances of causing sloughing or cauterizing of the mucous membrane. Tincture of iodin is one of the most efficient antiseptics and germicides known to modern surgery. When it is used on a surface containing bacteria it will destroy them and leave the tissue in the best possible condition for repair. The extra addition of alcohol is of value in reducing the standard tincture of iodin as is given in the U. S. P. formula, and has some germicidal properties. This solution can be applied very freely covering a surface from 2 to 5 centimeters in diameter. This antiseptic solution is applied to the surface by a pledget of cotton wrapped around a small wooden applicator, such as is used by the nose and throat specialist. This is an excellent medium and is inexpensive. After this technic has been carried out, the area should be protected and great care exercised so as not to permit saliva or any moisture to come in contact with the surface prepared for the reception of the needle.

PRELIMINARY AGENTS.

I HAVE FOUND it advisable in some cases for oral surgery to administer a preliminary agent to relieve the hypersensitive or hysterical patient of the feeling of anxiety, restlessness or apprehension. The preliminary sedatives which I have found to be of exceptional value in the execution of my anesthetic work are as follows: Validol, Bromural, bromides, and chloral hydrate. I find it is seldom necessary to resort to morphin as a preliminary agent. Bromural is an efficient nerve sedative and has no apparent action on the circulation or respiration. It is an agreeable hypnotic and sedative and can be administered without any after affects. It is best given in 5 grain tablets in warm water 30 minutes before the operation. Validol is a colorless substance insoluble in water. Therefore, it should not be added to water before administering to the patient. A very efficient method for giving this drug is to drop the proper dose, which is 7 or 8 minims, on a block of sugar. This has been suggested by Dr. C. Edmund Kells of New Orleans. The preliminary agent should be administed at least 30 minutes before operating.

I will now attempt to cover in a concise manner the technic for the injections under the intra- and extra-oral methods which are most important to the oral surgeon.

MANDIBULAR-LINGUAL ANESTHESIA. BLOCKING THE INFERIOR DENTAL AND LINGUAL NERVES—INTRA-ORAL METHOD.

HAVE THE PATIENT open the mouth as wide as possible, place your index finger against the ascending ramus allowing the palm of the finger to rest upon the occlusal surface of the lower teeth. Great care should be exercised to not mistake the dense connective tissue, which covers the anterior surface of the masseter muscle in some cases, for the ascending ramus. This can be overcome by having the patient open and close the mouth slightly, and should the index finger rest against the anterior surface of the masseter muscle it will be found that resistance will vary, whereas, if the tip of the index finger rests against the ascending ramus the resistance will remain the same. Next locate the external and internal oblique lines and the trigonum retromalare with the dorsal surface of the finger toward the median line. Allow the radial side of the index finger to rest upon the occlusal plane of the lower teeth. Now retract the mucous membrane beneath the finger to give ample room for the needle to pass the end of the finger nail. Now force needle through mucous membrane, striking the inner oblique line. The width of the average index finger is 2 cm. and when the mucous membrane is punctured at the middle of the finger nail, it makes an excellent guide in puncturing the mucous membrane in this location. The distance from the puncture of the mucous membrane to the periosteum covering the inner oblique line is about 5 mm. Allow the barrel of the syringe to rest over the bicuspids on the opposite side of the mouth. Be careful to keep the needle a distance of 10 mm. from the occlusal plane of the lower teeth. When the internal oblique line is reached with the needle, cross the median line to a point outside the arch on same side of injection. Be very careful not to allow the point of the needle to go beneath the periosteum. When the syringe is on the outside of the arch on same side of injection insert needle posteriorly about 5 mm. and inject ½ cc. of the solution so as to anesthetize the lingual nerve. The lingual nerve is located 5 to 7 mm. from the inner surface of the ascending ramus. Now bring the syringe back across the median line, this distance being governed by the amount of divergence of the two rami. Now insert the needle 10 mm. to reach the inferior dental nerve. If the syringe has been held in the proper position the point of the needle will reach the periosteum at an acute angle to the inner surface of the ascending ramus in the region of inferior dental foramen when at a depth of approximately 20 mm. Before injecting the solution into the mandibular fossa, it is well to work the syringe back and forth one or two millimeters and inject the solution only when the point of the needle rests against the periosteum.

Inject 1½ to 2 cc. of this solution for the inferior dental nerve. It is necessary, for best results, to work the syringe back and forth slightly at the time the solution is being discharged, in order to assist the tissue in absorbing the solution and not to cause a too rapid distention of the soft parts. The amount of solution used for inferior dental and lingual nerves in the average case is 2½ cc. If the operator is skilful in his technic, operations can be begun, in some cases, within five minutes after the injection. The needle used for this injection is 30 mm. long and 24 gauge, made of iridio platinum. Anesthesia will be secured in the greater part of the lower jaw.

The producing of anesthesia near the median line depends upon how rich the nerve supply is in this particular region between the inferior dental and lingual nerves on the injected side and their fellow nerves on opposite side. Following the blocking of the inferior dental lingual nerves on both the right and left sides of the mandible anesthesia is produced in the lower jaw in the greater percentage of cases. In a small percentage of cases the blocking of these various nerve trunks on both sides does not render insensible to pain the tissue in the region of the median line labial to lower incisors because the cervical plexus in a few cases supplies this particular region with nerve branches. When this is found to be the case, the incisive nerve-blocking injection is made by inserting the needle at the side of the median fold of mucous membrane and forcing the needle into the base of the left incisor fossa, then retract the needle without taking it out of the tissue, and force it down into the right fossa and inject the solution. Deposit 1 cc. in each fossa. The blocking of these nerves should be sufficient to enable the operator to extract all of the teeth, reduce a fracture, remove necrosed bone, remove pulps from the teeth, or remove a cyst or tumor either in the region of the mandible or from the soft tissues in the floor of the mouth.

BLOCKING THE SECOND DIVISION OF THE FIFTH NERVE—INTRA-ORAL METHOD.

THE WRITER WORKED OUT the technic for this particular injection some time ago and has used it in a large number of cases with satisfaction. This injection, with several others, was carefully worked out on the cadaver and they promise to be of exceptional value not only to the oral surgeon, but also the eye, ear, nose and throat specialist as well. The blocking of this large nerve trunk is an easy matter provided the operator is thoroughly acquainted with its technic. The maxillary or second division of the fifth nerve passes from the brain through the foramen rotundum and crosses the spheno-maxillary fossa entering the floor of the orbit. At this level the spheno-maxillary fossa from the foramen rotundum to the posterior part of the orbit is, in the average case, from 7 to 10 mm. in width. The needle is inserted into the region of the second division posterior to the floor of the orbit and the solution injected. The technic for this injection is as follows: Use a needle 40 mm. long, 23 gauge, attached to an extension hub having a certain curvature. The mucous membrane is punctured by the needle in the fold where the cheek blends with the gum tissue at a point superior and lateral to the upper third molar. The needle is now directed upward and inward keeping it in contact with the peroisteum covering the posterior lateral curvature of the tuberosity of the superior maxillary bone. This route is devoid of arteries and veins. The depth of the needle is approximately 3 cm. in the average adult case. The amount of solution used is 3 cc. Time to wait for anesthesia is from 5 to 15 minutes. Anesthesia is secured in all the parts which are supplied by the second division of the fifth cranial nerve. The following operations can be performed: Resection of the superior maxillary, extraction of teeth, reduction of a fracture, amputation of roots of teeth, establishment of drainage of curettement of the antrum, and nasal operations. If the opposite side is blocked operations near and involving the median line as well as on the opposite maxillary bone can be performed, including operations for harelip and plastic operations. Space does not permit me to take up the blocking of the smaller nerve trunks which are branches of the second division. These are blocked intra-orally and are of great importance to the oral surgeon.

EXTRA-ORAL BLOCKING FOR THE INFERIOR MAXILLARY OR THIRD DIVISION OF THE FIFTH NERVE.

THE SKIN THROUGH which the needle is to be inserted must be thoroughly prepared. The part must be thoroughly cleansed and followed with an application of bichlorid solution or tincture of iodin. I make an initial injection into the skin with a fine, sharp needle in order to eliminate the pain which would be caused by the regular needle for the deep injections. After this initial injection has been made the long needle is used, which is 23 gauge and 5 cm. long.

The following technic is employed. Have patient open and close mouth slightly. Locate the space between the lower portion of the zygomatic arch and the upper portion of the ascending ramus, between the coronoid process and the condyle of the mandible. The following landmarks are carefully followed. Before the skin is prepared draw a line parallel to the lower margin of the zygomatic arch directly above the sigmoid notch on the mandible. Connect the two ends of this line by following the lower border of the sigmoid notch. This will give a semi-circle and indicates the location of the sigmoid space. Puncture the skin with the needle in the center of this area, allowingthe needle to form a right angle with surface of skin. Now direct the needle inward to a depth of 4 cm., which is the average distance in most cases. The point of the needle should be anterior to the foramen ovale which transmits the third division of the fifth nerve. Inject 3 cc. of the solution. Anesthesia of the lower jaw on side injected should occur in from 7 to 15 minutes.

EXTRA-ORAL METHOD FOR BLOCKING THE SUPERIOR MAXILLARY OR SECOND DIVISION OF THE FIFTH NERVE.

THE BLOCKING OF the superior maxillary division of the fifth nerve in the spheno-maxillary fossa is as easily accomplished as the blocking of the third division. First locate the anterior surface of the ascending ramus and the anterior margin of the coronoid process of the mandible. Next locate the lower margin of the zygomatic arch in this region. Now draw a line along the lower margin parallel to the zygomatic arch. Next draw a line parallel and anterior to the coronoid process of the mandible, which is in a perpendicular position. A right angle is now formed. Now connect these two right-angled lines with another line thus forming a triangle. After the skin has been treated aseptically, a puncture is made with a fine needle in center of triangle for the initial injection. Then use the same needle as is used for blocking the third division. Direct the needle backwards, inward and upward for a depth of 20 mm. In the average case the point of the needle should strike the periosteum covering the posterior lateral tuberosity of the superior maxillary bone. At this point is located the posterior superior alveolar foramen containing the posterior superior alveolar nerve. The point of the needle strikes the periosteum thus indicating the needle is going in the right direction. Force the needle past the tuberosity 20 more mm.

The point of the needle should then enter the region of the second division of the fifth nerve within the spheno-maxillary fossa. The point of the needle should be located just posterior to the posterior-inferior margin of the orbital cavity while the solution is being injected. Inject three cubic centimeters. The depth of the needle in the average adult case is four centimeters. The needle should be five centimeters in length. Anesthesia is secured in most cases from five to fifteen minutes. The structures anesthetized include the following: All structures supplied by the second division of the fifth nerve such as the superior maxillary bone, teeth, antrum, gum tissue, portion of check, the periosteum and half of palate.

EXTRA-ORAL METHOD FOR BLOCKING THE INFRA-ORBITAL AND ANTERIOR SUPERIOR ALVEOLAR NERVES.

LOCATE THE infraorbital foramen with the index finger, then bring it down allowing it to rest directly over the foramen which is located at a point 1 centimeter beneath the infra-orbital margin. Use a fine sharp needle as described heretofore for the initial injection. Now follow the initial injection with the regular needle which is of iridio-platinum, 24 gauge and 3 centimeters long. The injecting needle is now forced upward and backward to a depth of 1 centimeter in the majority of cases. Inject 2 cubic centimeters of the solution at the opening of the infra-orbital foramen. Next massage the skin directly over the area injected, thus forcing the solution backward into the infra-orbital canal to a distance of 5 millimeters in most cases thus allowing the solution to come in contact with the anterior superior alveolar nerve. Anesthesia is secured in the following structures in less than 5 minutes; central, lateral and cuspid teeth, side of nose, upper lip, alveolar process, labial tissue, anterior wall of antrum, and periosteum providing the anastomoses is blocked on the opposite side of the median line and of the middle superior alveolar nerve branch.

Local anesthesia may be employed for any operation around the face or about the jaws provided the operator understands his anatomy and is careful and exacting in his technic. It is absolutely necessary for the operator to know what nerves are to be blocked and how extensive an area of anesthesia must be produced in order to operate without inflicting any pain during the operation. If the operation is for the removal of a malignant growth or even a benign condition or the curetting of necrosed bone or treatment of empyema of the antrum, local anesthesia has an advantage over a general anesthetic for the reason that in most cases the patient will consent to an earlier operation. Last but not least one may add that nerve blocking anesthesia renders the area of operation less bloody and the operator is not handicapped by a general anesthetic mask. Many anesthetists and oral surgeons who have familiarized themselves with this method of anesthesia state that it has many advantages over general anesthesia in nearly all cases and they will not abandon it for the general method.

NERVE BLOCKING ANESTHESIA FOR TONSILLECTOMY.

DURING THE past few years I have spent considerable time in working out a nerve blocking technic for the removal of the tonsils. My findings along this line have been very satisfactory and it gives me great pleasure in presenting this technic to the eye, ear, nose and throat specialist. We are well aware of the fact that the medical man has not followed a definite system in injecting the solution. He has injected the solution promiscuously into the pillars of the tonsil and tonsillar tissue and in many instances the tissue has been in a state of degeneration containing pus and necrotic material. We are aware of the fact that when solution is injected into tissue of this character there is great danger of disseminating infection and carrying infected material into healthy tissue. I am quite sure that no learned dentist would be guilty of injecting solution into inflamed tissue or an alveolar abscess. It is impossible for me to give the detailed technic for blocking the tonsils by the deep blocking method but I will attempt to give the nervous anatomy and a brief outline of the technic. The tonsil derives its nerve supply from two different sources. Its principle nerve supply comes through the branch of the glosso-pharyngeal which unites with the branches from the pharyngeal plexus thus forming the tonsillar plexus which is located at a point posterior and lateral to the base of the tonsil. The second supply is from Meckel's ganglion which is located in the spheno-maxillary fossa, which gives off a number of branches. The branches which interest us just now are the nasal, pharyngeal, naso-palatine, anterior, middle and posterior palatine. The anterior palatine passes through the posterior palatine foramen and supplies the tissue in the soft and hard palate communicating with the naso-palatine branch which passes through the anterior palatine thus forming the inner nerve loop. The middle palatine nerve is distributed to the mucous membrane of the soft palate, uvula, and palatine tonsil. The posterior palatine branch supplies the mucous membrane of the tonsil, soft palate, uvula and a portion of the pillars. The technic for blocking the tonsil is as follows: The plexus tonsillaris and the pharyngeal plexus are located posterior and lateral to the base of the tonsil. These structures are blocked by inserting the needle midway between the occlusal surfaces of the upper and lower teeth, puncturing the mucous membrane at the base of the tonsil beneath the plica semilunaris and directing the needle backward and laterally to a depth of approximately 2 cm. Two cubic centimeters of the solution is injected. The other nerve supply of the tonsil which is from branches of Meckel's ganglion is blocked in the same manner as given above in the technic of blocking the second division of the fifth nerve by the intra-oral method, with the exception that the needle is not forced in to the depth of 3 cm. but 2 centimeters in the average case thereby anesthetizing the palatine branches which are located in the spheno-maxillary fossa. We are aware that it is difficult to carry out the technic on a very young person unless the operator can obtain and maintain the confidence of his little patient. In my opinion this method proves of exceptional value for the removal of tonsils and will prove of great advantage in many cases over general anesthesia.

THE ANESTHETIZING SOLUTION.

FOR MY ANESTHETIZING solution I employ in most cases Novocain-Suparenin-Ringer solution. I use only freshly distilled sterile water adding the proper number of tablets at the time of operation to give the proper percentages of the vaso-constricting agent and anesthetic. The tablet contains all the ingredients, *i. e.*, novocain, suprarenin and Ringer's constituents. In most cases a 2 per cent. solution is employed. A stock Ringer solution is not employed.

An isotonic anesthetic solution composed of known amounts of ingredients corresponding to the physiological laws of osmotic pressure and functions of the living cell should always be employed.

I trust that this simplified technic presented here for extra-oral methods will be of some value to the oral surgeon and to the general practitioner. It has been by pleasure to carry out considerable research work on cadavers and it has been the aim to make the technic simple and practical, combining efficiency with ease for blocking the various nerve trunks.

In addition to the research work on cadavers, I have also been working out the comparative toxicity of a number of the local anesthetics which are at our disposal and hope to publish this report in the not distant future.

In conclusion allow me to state that it is the duty of every dentist to study and apply that which the sciences of medicine and chemistry offer, and the day for the practitioner to inflict pain upon his patient is rapidly passing, and sooner or later they will grasp the tool of efficiency and travel with the modern trend. It is self evident that an operator can render better service when the patient is free from pain and last but not least every individual will appreciate such service. When service can be successfully and painlessly rendered without endangering the health of the patient, it is always advisable, for any agent that has for its object the relief of pain is worthy of our earnest consideration and study. The constant aim of the conscientious practitioner of Medicine and Dentistry should be to assuage the pain to which mortality is heir and put forth every effort in combating disease and pain, not from a remunerative, but from the humanitarian standpoint. It is this uplifting and consecrated zeal, akin to veneration for the profession which should be dear to him and which has given the world the masters of the profession.

RIETHMULLER, who has done much to popularize conductive anesthesia in the United States, discussed its causes of failure and untoward results before the Joint Meeting of the Interstate Association of Anesthetists and the Mississippi Valley Medical Association, Toledo, O., October 9-11, 1917; and also before the Annual Meeting of the Ohio State Dental Society, Cleveland, O., December 4-6, 1917, publishing his matured opinions and conclusions in the American Journal of Surgery, Anesthesia Supplement, July-October, 1918. Riethmüller is now firmly convinced that:

Unlike numerous *innovations* in dentistry, conductive anesthesia has successfully steered past the shallows and cliffs of *fadism*. Surprisingly few indeed have been the open admissions and reports of failure or untoward results arising from the employment of this method, although the men who have been pioneers and instructors in this doctrine know very well, from consultations and daily correspondence, that disappointments and failures have been attending the efforts of their followers and pupils. To point out the most prevalent and most likely pitfalls that may be encountered in the routine practice of conductive anesthesia, is the purpose of this investigation.

Conductive anesthesia has by no means had an easy road to acknowledgment. The manufacturers of apparatus and the professional advocates of general anesthesia were for several years so busy deprecating the appearance and the advocacy of conductive anesthesia that, in their blind zeal, they heaped a full measure of wrath upon conductive anesthesia—usually without knowing the first principles about it—ruined their own stock-in-trade by belittling the intricacies and exacting requirements of general anesthesia, and overlooked entirely such moderate and truly fair statements as that made by the writer in Dental Cosmos, July, 1915, that *"no dental operator who is familiar with but one method of anesthesia should consider himself competent in anesthesia, nor can any dental office which offers anesthetic facilities of but one kind be regarded as efficiently equipped."*

REQUIREMENTS OF AN IDEAL LOCAL ANESTHETIC.

IT APPEARS THAT so far none of the homologues of novocain or the many possible modifications of the synthetic substitutes for cocain measures up to the selected few local anesthetics adopted by the medical profession, for which Braun has set the following standard:

1. The substance must be less toxic than cocain in proportion to its local anesthetic power.

2. The agent must not cause the slightest irritation or tissue injury, but must be absorbed from the place of application without any secondary effects such as severe hyperemia, inflammation, painful infiltrates or necrosis. Only when these conditions are fulfilled can we assume that the healing of wounds will not be interfered with. The use of strongly acid or alkaline substances is not permissible, inasmuch as they cause local tissue injury. On account of this important requirement many of the newer anesthetics have failed in their purposes.

3. The agent must be soluble in water and its solutions stable and possible of sterilization by boiling.

4. It must be possible to combine the agent with suprarenin.

5. For particular places of application, as for

instance, mucous membranes, the anesthetic must be able to penetrate rapidly, its anesthetic properties being dependent upon this quality.

NOVOCAIN-SUPRARENIN SOLUTIONS.

COMING NOW TO the actual causes for failures in conductive anesthesia, the preparation of solutions merits special attention. Stock solutions or proprietaries are *a priori* objectionable, since their keeping property depends upon antiseptics of some kind or other which, when injected, act unfavorably upon the tissues and frequently produce after-pain or even sloughing. As long as these concoctions are administered by way of infiltration only, the possible damage, which is of necrotic nature, may be confined to relatively superficial strata of tissue; for conductive anesthesia, however, their employment involves serious risk. The remedial alleviation of such untoward results, moreover, is complicated by the operator's ignorance of the quantity and nature of the antiseptics admixed, placing him in an extremely disadvantageous position medico-legally. Conscientious operators will strictly adhere to the principle that, if a patient is worth while treating, he is worth while making a fresh solution of definite constituency and percentage for.

Attempts have been made to combine the physiologic amount of sodium chlorid or Ringer ingredients with novocain-suprarenin to save the time and trouble of making a normal salt or Ringer stock solution separately. This like other admixtures is contraindicated as the combination of NaCl and suprarenin is unstable, and such combination tablets almost invariably yield discolored solutions.

This disadvantage was pointed out by the writer as early as 1914 (Dental Cosmos, December, 1914): "The addition of sodium chlorid to novocain-suprarenin tablets for the purpose of simplifying the preparation of isotonic solutions as practiced by some drug houses, should be discouraged, since they give discolored solutions within a very short time after purchase, and especially after a tube has been broached, proving that the combination of novocain-suprarenin and sodium chlorid is very unstable, chiefly owing to the hygroscopic property of sodium chlorid."

Nevertheless, a United States Patent upon this combination in principle has been granted.

Improper methods of preserving the tubes in which tablets are marketed, are a prolific source of annoyance to the operator. Prolonged exposure to heat, light and moisture results in decomposition of the tablets despite the precautions in packing exercised by the manufacturers. Dentists as a rule are very careless in their manner of preserving drugs, as a glance at the carbolic acid, silver nitrate, hydrogen peroxid or iodin contained in the average medicine cabinet will attest. The writer has been able to preserve tubes of novocain-suprarenin tablets without decomposition for years by placing his stock in a tightly closed Mason jar set in an equally tight tin bucket, which combination seems to act as a sort of improvised thermostat when set away in a dark, cool closet of even room temperature. Additional stability of tablets is insured by dipping unbroached tubes into a solution of low-melting paraffin. Not more than one tube is ever broached at one time, and the sterile cotton and rubber stopper are immediately replaced under aseptic precautions. Prolonged direct contact between the uppermost tablet and the rubber stopper results in a reaction between the tablet and the sulphur in the rubber as manifested by brown discoloration of the tablet. It seems also that tablets prepared and packed during humid summer days are more prone to discoloration than those made up during the cooler months.

Discolored solutions are viewed by most operators with suspicion and rejected. When this discoloration is due to intrinsic decomposition of the tablets or to organic contamination or alkalinity of the distilled water or the dissolving cup, this attitude is not only justified, but imperative. If, however, all precautions of asepsis have been carefully followed, and the solution which immediately after boiling was clear assumes a pinkish shade attributable to oxidation, heat and light, it may be employed with impunity. The writer has never observed any toxic symptoms following the injection of sterile though slightly discolored solutions. It goes without saying, of course, that dust, particles of saliva distributed in the air by breathing and speaking, or alkaline vapors from soap and sodium bicarbonate which ever pervade the air of an operating room must be excluded by covering the dissolving cup with a plate of colored glass or of porcelain, which is readily sterilized by passing the surface which comes in contact with the rim of the cup over an alcohol flame.

It has been observed that some operators fill their dissolving cup with Ringer solution, add the

Fig. 1. Author's improved container for Ringer Solution.

novocain-suprarenin tablets to the cold solution and boil. This procedure is reprehensible because the tablets come in almost direct contact with the flame at the bottom of the cup where they are roasted, as it were, long before the Ringer solution approaches boiling point. Such combined roasting and unduly prolonged boiling greatly impairs the clearness and stability of the resulting solution.

If hydrochloric acid is used to overcome the alkalinity of ordinary glass containers, great caution is advised not to over-acidulate, since intense and prolonged after-pain will follow injection of such solutions. Alkali-free glass containers are now readily obtainable.

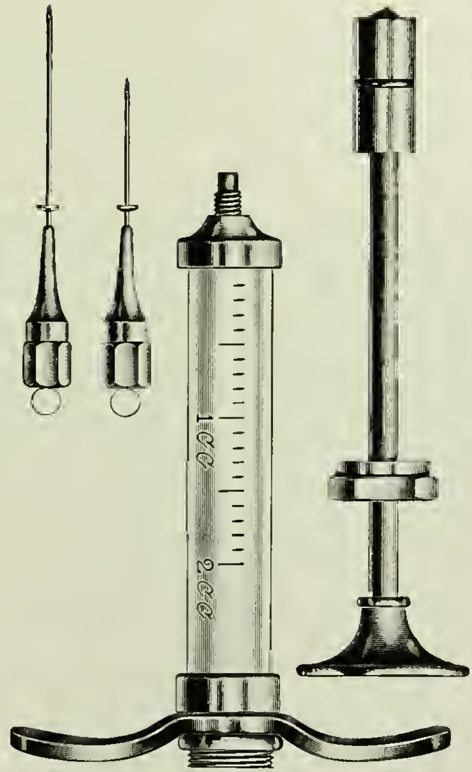


Fig. 2. This syringe holds 2½ cc. In its design, delicacy and lightness have been prime considerations. It is an all glass and metal syringe without washers of any kind, which for purposes of sterilization is taken apart in two sections. The glass and metal are annealed in such a way as to permit of vigorous prolonged boiling. All gnarled corrugated surfaces are avoided, and all corners are rounded off and the piston is made to end in a graceful indeuted end in which the ball of the thumb fits snugly. The cross-bar moves readily and the barrel is long enough so that the operator's second and third fingers find ample working space between cross-bar and cheek so as not to obscure the field of vision. Although very light pressure only is required in conductive anesthesia, the syringe is tested to 30 pounds pressure so as to allow of infiltration without regurgitation. To prevent the migration of a broken needle into deeper strata of tissue, the needles have been provided with a safety disc, wider than the lumen of the needle perforation, so that the needle fragment is automatically arrested. Since, according to the laws of mechanics, the needle, no matter whether of steel or iridio-platinum, must break at the orifice of the hub to which the needle is attached, the risk of losing a needle is eliminated, which fact may be especially appreciated by the beginner. To facilitate finding the inclination of the bevel of the needle, a mark is placed on the hexagonal hub in such a way that visibility of the mark indicates pointing of the bevel of the needle toward the bone. To avoid confusion the hubs of steel needles are nickel-plated, those of iridio-platinum are gold-plated.

DISTILLED WATER.

THE USE OF contaminated distilled water of the average drug store variety cannot be too severely condemned, as it is conducive to after-pain, sloughing and even suppuration, as has been demonstrated by animal experimentation. The most satisfactory distilling apparatus is one of glass of the sort devised by Dr. Silverman and others. The first portions of the distillate should always be rejected, as it contains dust and carbon dioxid accumulated in the still. If any doubt exists in the operator's mind as to the absolute purity of the distilled water used by him, he should subject it to the simple tests prescribed by the U. S. Pharmacopeia. The operator's stock of distilled water is to be kept in a double, groundglass, stoppered, non-alkaline glass flask covered by a hood of sterile gauze. Ringer stock solution can be kept sterile for weeks in the non-alkaline glass stock bottle designed by the writer, and herewith illustrated, into which air is admitted only through a wad of sterile cotton held over the small holes in the stop-cock and intake which are brought into line by a turn only when Ringer solution is actually needed. It is good practice to renew Ringer solution every week, sterilizing it in a water-bath after removing stop-cock and nozzle hood and protecting the two outlets of the bottle with sterile cotton or gauze.

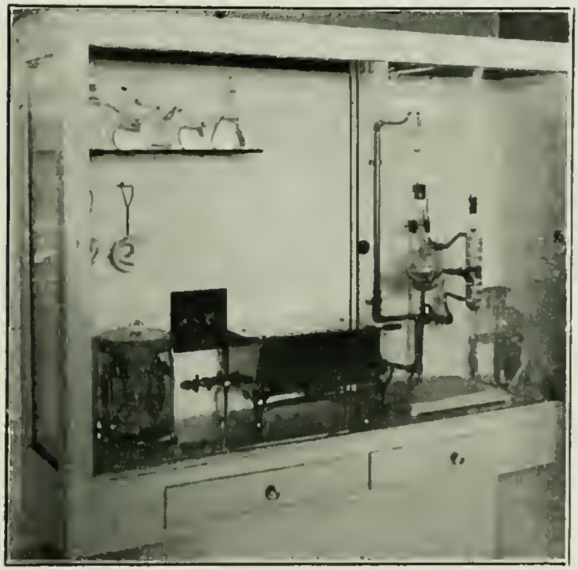


Fig. 3. Aseptic wall-cabinet for storing water-still instrument sterilizer, syringe jars, boiling cups and flasks of distilled, sterile water.

TOXICITY OF NOVOCAIN-SUPRARENIN SOLUTION.

A GREAT DEAL HAS BEEN said and written about the toxic symptoms produced by novocain-suprarenin solutions, and their appearance is usually, though wrongly, attributed to the admixture of suprarenin. Braun, and quite recently again Silverman, have conclusively shown that this toxicity is not due to the suprarenin but to the novocain itself. This is also borne out by the study of G. B. Roth, of the U. S. Public Health Service, who states that "*the depressing effect of novocain on the blood pressure and respiration of animals makes it necessary to use caution in its administration in clinical cases in which the blood pressure is low or in which the heart is at fault,*" and that "*great care should be exercised in the injection of novocain subcutaneously, in order to avoid entrance into the circulation, thereby increasing its toxicity.*" In this connection it is advisable, however, to remember Mayo's timely warning that animal experimentation is not conclusive proof and that

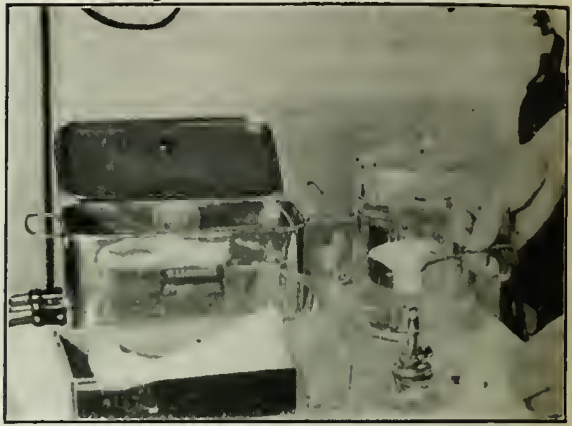


Fig. 4. Table and equipment devoted exclusively to the preparation of novocain-suprarenin solutions. Sterilizing solution in porcelain cup over an alcohol flame.

clinical observation in man alone can arrive at the truth which the test tube brigade can only distantly sight in their experiments on frogs, rats, cats and guinea-pigs. The writer's own clinical observations tend to emphasize the advantage of a tablet of a higher percentage of suprarenin in longer anemia produced by tablet *E* is of decided advantage to the oral surgeon in regard to better visibility of the field of operation. The disadvantage of this anemia as far as clot-formation and wound-healing are concerned, are fully overcome by manipulation, massage or scarification

Figs. 5-6. Right Tuberosity Injection.—The posterior and middle alveolar foramina, located back of the maxillary tuberosity, below and behind the zygoma, give passage to the posterior and middle superior alveolar nerves, innervating the soft tissues facially, the bone and pulps of the first, second and third molars, and first and second bicuspids. The needle is inserted in the reflection of the mucous membrane hack of the distal root of the first molar and advanced on the hony surface without discharging solution—in an upward, backward and inward direction. When the needle is inserted to full length, 3-4 of the contents of the syringe are discharged. If the bicuspids are also to he obtunded the remaining 1-4 of the syringe contents is discharged as the needle is withdrawn. Patient's head in reclining posture; mouth closed, cheek retracted. Quantity of solution 2 cc.

the dental tablet *E*, giving the stimulating effect of that drug, over the lower percentage in tablet *T*, except in hyper-thyroidism or patients with high blood pressure. The more pronounced and of the wound ensuring a free flow of blood before completion of the operation.

Slow injection with just enough pressure to evacuate the syringe is the most efficient means for avoiding toxic symptoms which occur far more frequently in the infiltration of small quantities of solutions under excessive pressure, than in the deposition of incomparably larger quantities under practically no pressure in conductive anesthesia.

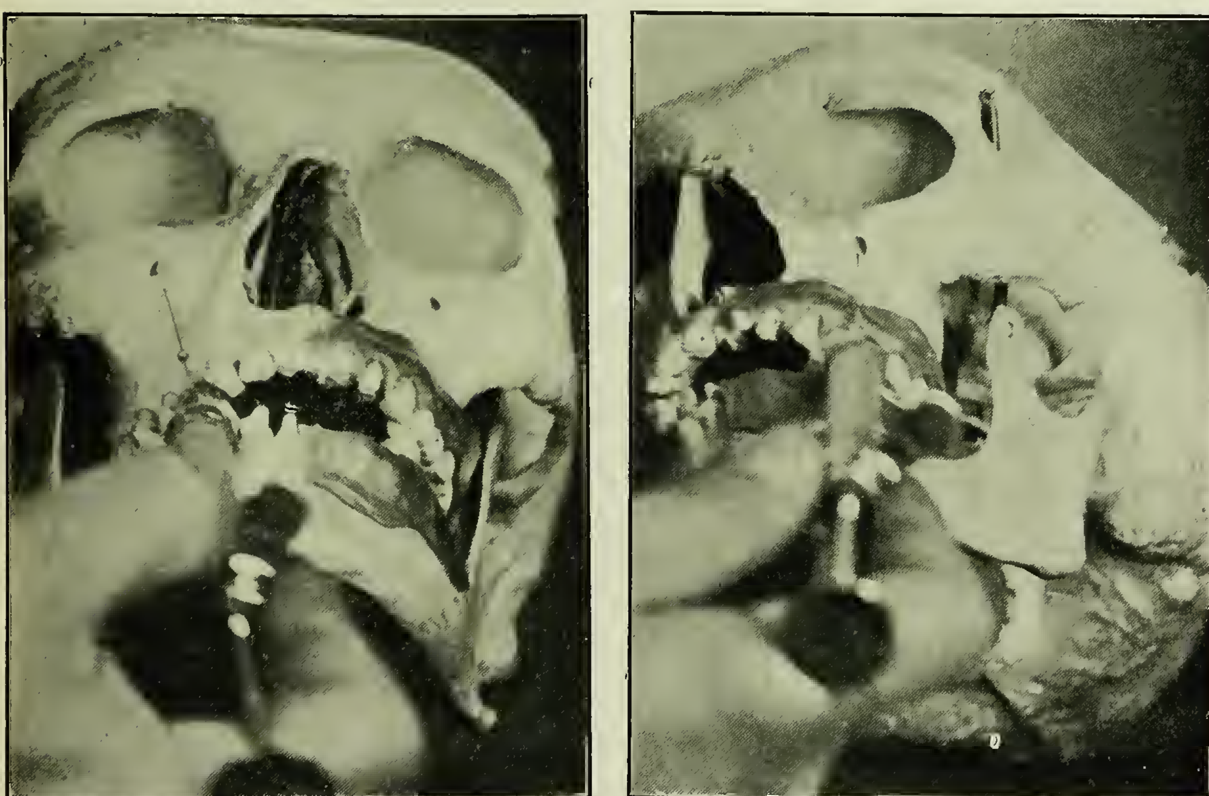
Figs. 7-8. Left Tuberosity Injection.

Both the operator's and the patient's individualities determine to a large degree the character and intensity of toxic symptoms which accordingly may vary from slight pallor to syncope. Proper diagnosis and selection of cases from physical, pathological, racial, social and psychic points of view are of paramount importance in the avoidance of untoward results. This phase of the question, which may be summed up in the word *shock*, has been treated in the writer's paper on "Anoci-Association in Dentistry" (Dental Cosmos, July, 1915), where the choice of anesthetic, preoperative medi ation and therapeutic measures in collapse are discussed in detail, also in "Local Anesthesia in Dentistry" under the heading of "Accidents Following Novocain Injections." As a primary measure of precaution, patients who are to be subjected to local anesthesia should always be specifically advised to eat a hearty meal previous to presenting themselves for dental or surgical operations. This precaution, which is contrary to our methods of preparing patients for general anesthesia, will practically eradicate all tendency to faintness.

The usual symptoms of toxic effects in the various types of patients may be briefly summed up as follows:

Weakly anemic patients are prone to pallor and slight trembling of the extremities, which passes off rapidly with deep breathing, or the internal administration of aromatic spirits of ammonia or camphorated validol, or upon the inhalation of strong ammonia or amyl nitrite, ethyl chlorid or ether. In *cardiacs,* distressing sensations in the heart region, shallow and rapid respiration and the appearance of perspiration on the forehead are noted, these symptoms quickly disappearing. The *bilious temperaments* seem to be most pronouncedly affected, but in these also as well as in advanced stages of *nephritis,* slow injection of 1 per cent. solutions and the operator's reassuring attitude help the patient rapidly across the first five critical minutes within which toxic symptoms usually appear.

In persons with *high blood pressure,* the administration of mild narcotics previous to injection insures good results. Bromural "Knoll" (alpha-bromisovaleryl-urea) 2 tablets equal 0.6 gram, to be taken with water 30 minutes before making the injection has given the writer greatest satisfaction, although other sedatives such as chloral hydrate, morphine in conjunction with scopolamin or hyoscin have their advantages.



Figs. 9-10. Right and Left Infraorbital Injections.—The infraorbital foramen, emitting, the anterior superior alveolar branch, innervates the soft tissues facially, the bone and pulps of the central, lateral incisors and the canine. Owing to anastomosis of the middle superior alveolar branch the first bicuspid is also obtunded. Palpate lower border of orbit on face, press index finger over infraorbital foramen. The needle is inserted in the reflection of the mucous membrane distally to the canine root, advancing needle to about ½ its length, while continually discharging solution until the needle is felt under the palpating finger. Patient's head in reclining posture, mouth closed, upper lip retracted with the thumb. Quantity of solution 1 cc. to 1.25 cc.

In *neurotics or hysterics,* the problem is of course a much more complicated one, since we are dealing with psychopathic conditions, in the successful treatment of which the operator's personality in its appeal to the patient's psyche is a deciding factor.

Epileptics can be treated successfully if the operator will select the period half-way between the usually chronically occurring attacks. As a matter of gratification the writer wishes to state that in his clinical experience, including every imaginable *bad risk,* he has observed but two disconcerting reactions in neurotics.

Children seem practically immune to both 1 and 2 per cent. solutions, which, of course, is accounted for by the fact that usually the robust and healthy are the courageous ones who do not fear the needle, or that the operator by a few kind words striking the level of the childish mind gains the little patient's full confidence. It is remarkable indeed how devoid of any toxic reaction conductive anesthesia can be practiced on the children of the slums or inmates of asylums and tuberculosis institutions, whose physical condition is far below par.

Within 14 months of tri-weekly attendance as surgeon to the Department of Oral Surgery of the N. Y Throat, Nose and Lung Hospital and to the Lenox Hill Hospital Dental Dispensary I have observed but one case of fainting in an undernourished and nervous girl of 15 years of age, faintness being due to unduly rapid injection and lasting but three minutes. Previous to that, I have had occasion to observe tendency of fainting in a hysterical young woman, Italian, 17 years of age, as Instructor in the Dental Department of the Medico-Chirurgical College of Philadelphia, and again as Instructor in the Post-Graduate School of Philadelphia in a man of 40 years who had made up his mind and signified his intention to faint.

INSTRUMENTARIUM.

THE NECESSITY OF asepsis of instrumentarium requires no special accentuation, although the lack thereof is one of, if not *the*, most common causes of after-pain and infections. Simplicity of instrumentarium engenders continuity of the delicate chain of asepsis, breaks in which are the more likely to occur the more complicated the apparatus used. All-glass-and-metal syringes without washers of any kind permit of most simple and effective sterilization. The liquid most suitable for keeping sterilized syringes in is 70 per cent. alcohol with admixture of a small quantity of glycerin, which must be washed out from the inside of the barrel by drawing in it boiling distilled water several times to

Fig. 11. Left Anterior Palatine Injection.—The anterior or incisive foramen is located in the median line back of the incisive papilla and emits the nasopalatine nerve, innervating the soft tissues palatally from canine to canine. The needle is inserted a short distance anteriorily to the incisive papilla, injecting under light pressure, advancing cautiously and slowly to a short distance posteriorily. Patient's head in reclining posture; mouth wide open. Quantity of solution 0.25 cc. or ⅛ contents of syringe.

avoid the introduction of alcohol into the tissues and causing unduly prolonged anesthesia of the injected area due to the well-known action of alcohol on nerve tissues. Experiments with sterilizing fluids other than frequently renewed alcohol have proven unsatisfactory. Formaldehyde solutions especially are contra-indicated on account of their action upon novocain and the severe pain induced by the accidental subcutaneous injection of even minute quantities.

In the selection of needles, those of small lumen are preferable, as a stout needle manifestly is more liable to cause pain and traumatism on introduction. The extremely disagreeable accident of breaking a needle, which occurs most frequently in mandibular injections, is robbed of its terrors by the safety needles designed by the writer and herewith illustrated. These needles are constructed so that the break, if it occurs *in vivo,* comes to lie back of the safety disc, which prevents the fragment from disappearing in the tissues. Iridio-platinum needles seem most suitable for private practice, as they do not rust and are easily sterilized after every insertion by drawing through an alcohol flame, while steel needles clog unless a wire is inserted after every use; require at least 30 minutes' boiling to be sterile, and even then may rust and break anywhere along the course of the cannula. The sterilization of steel needles can be very quickly accomplished if instead of boiling, the needles are dipped in a vessel containing molten Wood's or Melotte's metal. This method is based upon the argument that the needle is exposed practically to the heat of the flame in the absence of atmospheric air, thus preventing oxidation and loss of temper while destroying even the most

Figs. 12-13. Left Posterior Palatine Injection.—The posterior palatine foramen is located in the palate on a line joining the last molar teeth present; it emits the anterior palatine nerve innervating the soft tissues palatally from the third molar to the first bicuspid inclusive. The needle is inserted as for infiltration of the palatal root of the last molar, then advanced slightly toward the foramen, while discharging drops of solution. There is danger of going too deeply and directly into the foramen. The patient's head is in the reclining posture, mouth wide open. Quantity of solution 0.25 cc. or ⅛ contents of syringe.

virulent bacteria. The carrying of infections by needles from one part of the mouth to another or from mouth to mouth, is criminal negligence, and, it is to be hoped, of rare occurrence.

The syringe and safety needles designed and used by the writer have given him and a large number of practitioners full satisfaction.

METHODS OF CONDUCTIVE ANESTHESIA.

ALTHOUGH VARIOUS ATTEMPTS have been made by operators and teachers to attach their name to modifications of the technic of conductive anesthesia, it should be emphasized that all these modifications have been foreseen by Braun upon whose painstaking researches conductive anesthesia is based. Since this basis is an anatomical one, there can be little variation or improvement over the basic principles established by Braun and adopted for dental practice by Fisher, Williger, Bünte, Moral, Seidel and others. It is feared that a confusion may arise in the beginner's mind as to specific merits of any one so-called method; in fact, the many questions addressed to the writer in that respect seem to indicate that the confusion has already started, which is surely not to the best interest of standardization which the dental profession is so eagerly striving to attain. The prime requisite for successful technic is a thorough familiarity with the anatomy of the head, and it is rather a slur upon the dental profession that certain *shotgun* drugs are advertised as requiring no special knowledge of dental anatomy for successful administration. Not only should this familiarity with the anatomy of the parts concerned be acquired from general and special textbooks, but practical experience on patients is paramount. Anatomic specimens are of great value, but better yet is the dissection of a green head after previous injection of some dye-stuff at the foramina concerned. In this manner the student becomes acquainted with the arrangement of the tissues upon which he is working.

ANESTHESIA OF THE UPPER BICUSPIDS.

REPORTS CONCERNING THE extent of anesthesia produced by tuberosity injection seem to vary as widely as the opinions of anatomists regarding the course of the superior middle alveolo-dental branch. This branch, if it exists—and some anatomists claim it does not—may present the following variations in course. It is either given off from the large infraorbital branch within the infraorbital canal and runs from there in the mucosa of the maxillary antrum to the upper bicuspids without appearing upon the facial surface of the maxillary bone; or it is inserted together with the posterior branch at the cribriform plate; or it is inserted in foramina situated anteriorly thereto. The examination of numerous skulls and clinical observations tend to point out that the latter two conditions are present in at least 75 per cent. of cases. If the long needle is inserted in the reflection of the mucous membrane back of the distal root of the first molar, in other words, between first and second molars, and advanced on the bony surface, without discharging solution in an upward, backward and inward direction at an angle of about 45° with the masticating surfaces of the upper molars, and 1½ cc. of solution are injected when the needle has been introduced to full length; if then in slowly withdrawing 1 cc. of solution is discharged as the needle is withdrawn, thus leaving a deposit of solution from the cribriform plate to the reflection of the mucous membrane; then, the three molars and two bicuspids together with the soft tissues connected therewith are satisfactorily anesthetized. It is of little practical value to argue how this anesthesia is obtained. Suffice it to say that either the posterior and middle branches are blocked simultaneously at the cribriform plate or, if the middle branch is inserted in its own foramina anteriorly to the cribriform plate, it is blocked there as the needle is withdrawn, or if the middle branch descends within the antrum, enough solution penetrates the canaliculi in the cortical facial bone to produce bicuspid anesthesia. If the first bicuspid is only partly anesthetized, as happens in some cases, this is due to the anastomosing fibres of the anterior branch. Most operators seem to insert the needle too far posteriorly and at too obtuse an angle, thus getting way beyond the cribriform plate, and yet not deeply enough into the spheno-maxillary fissure to block the maxillary branch *in toto*. Stern's suggestion of using the long needle in the bayonet-shaped hub has not given any better satisfaction. In all cases where the operator attempts an injection at a very obtuse angle a great deal of his solution seems to be deposited in the very heavy layer of areolar tissue overlying the cribriform plate and filling the spheno-maxillary fissure, so that very little solution is left for blocking the nerve branches. This will also explain the observation of some operators who obtain only partial anesthesia of the first molar.

Figs. 14-15. Left Anterior Palatine Injection.—The anterior or incisive foramen is located in the median line back of the incisive papilla and emits the naso-palatine nerve, innervating the soft tissues palatally from canine to canine. The needle is inserted a short distance anteriorly to the incisive papilla, injecting under light pressure, advancing cautiously and slowly to a short distance posteriorly. Patient's head in reclining posture; mouth wide open. Quantity of solution 0.25 cc. or ⅛ contents of syringe.

PAIN DUE TO INJECTION.

ANY PAIN CAUSED by the insertion of the needle is directly attributable to faulty technic. The only tissues which may be sensitive to the passage of the needle are the mucosa and sub-mucosa. For the rest the needle should advance slowly through areolar, soft, fatty and connective tissues which have no sensory innervation. The mucosa and submucosa are rendered insensitive, at the same time sterilized, by the topical application of the iodin-menthol-benzol mixture suggested by the writer (iodin crystals, 10 parts; menthol crystals, 10 parts; benzenum U. S. P., 80 parts). This stable solution will not produce the sloughing following the application of ordinary tincture of iodin which must be not older than one week, else it will decompose into hydriodic acid, while benzol will preserve iodin indefinitely. This iodin-menthol-benzol mixture is also a valuable indicator as to whether a patient is suitable for conductive anesthesia. Nervous patients and children who object and utter complaints upon application of this solution, which has a slightly smarting then cooling effect, are best subjected to a general anesthetic.

Another source of pain during the insertion of the needle, which, it goes without saying, must be kept sharp, is scraping along the periosteum, which is extremely disagreeable to the patient. Picking up of the periosteum by the needle point which is extremely painful is avoided in the novocain safety needle illustrated in Figure 2 by the mark placed on the hexagonal hub in such a way that the operator is always able to determine whether the bevel of the needle, which gracefully slides over the periosteum without engaging it, is in the proper position, that is, the bevel of the needle pointing toward the bone, no matter how deeply the needle may be inserted in the tissues. Forcing the needle through muscular tissue causes a dull, yet pronounced enough pain. The infringement upon a nerve trunk is expressed by a very sharp, sudden and intense pain resembling the application of a cautery. As soon as any of these painful sensations arise, indicating that the needle is traveling on a wrong course, a slight withdrawal and subsequent alteration of the direction will immediately overcome resistance and start the needle on its painless way through areolar tissue, which causes the sensation of an advance into butter, while bone offers rigid, muscle and nerve tissue an elastic rubber-like resistance. The needle always must be manipulated during insertion in the manner of a slender probe enabling the operator's delicate sense of touch to determine at any stage what kind of tissue the needle is engaging. Operators who have for years practiced infiltration anesthesia exclusively are often in the habit of causing undue amount of pressure and jabbing, which is extremely disagreeable to the patient and dangerous.

INFILTRATION.

WHILE ON THE subject of infiltration, it should once more be pointed out that this method is superannuated. The undue pressure required in infiltration is liable to produce tissue lesions; the result in the lower jaw is disappointing; each tooth requires individual infiltration, opening up possible passages for infection; the periosteum may be ripped from the bone resulting in intense after-pain and possible necrosis; and most important of all the contents of a focus of infection hidden in the cancellated bone may be forced into deeper strata and the circulation and, revived by the ideal culture medium of Ringer solution, may act in the manner of an active bacterin leading to grave local and constitutional symptoms such as necrosis, osteomyelitis, cardiac disturbances, nausea, malaise and syncope. These risks are usually not present in infiltration on the palatine surface, where it is only necessary to infiltrate the soft tissues under pressure no greater than that required to keep the solution in contact with the tissues.

INFECTED AREAS.

AREAS WHICH ARE not *bona fide* healthy are not suitable for injection. If a foramen can be reached by the extra-oral method, this method may be of great value if the patient will give his consent. As a rule, however, patients are laboring under the false impression generously fostered by the medical profession, that the interior of the mouth and its contents are the dentist's exclusive realm. All general infections of the mouth are an absolute contra-indication to intra-oral injections. Pus carried by the needle to great depth may set up violent local and systemic intoxications and even prove fatal. Several such cases are on record.

FAULTY METHODS OF OPERATION.

BEFORE PROCEEDING TO operate, the actual establishment of perfect anesthesia must be ascertained by pressure, or pricking or, if indicated, lancing with a suitable instrument within the area to be operated upon. If the slightest doubt exists as to the profundity of the anesthesia, comparison with corresponding non-anesthetized areas will give valuable indications. All anastomosing branches must be carefully considered, else the scalpel, curette, or bone forceps may suddenly invade an area in which sensibility persists. In mandibular injection the long buccal nerve, and in lower anterior teeth the anastomosis from the opposite side must be considered and, if necessary, abolished by an injection in the region of the molars or at the mental foramen of the opposite side respectively. The pain incident to prolonged retracting and stretching of the lips and muscles is combated by superficial injection under the mucous membrane of the cheek in the first molar region. In upper anterior teeth the anastomosis from the opposite side is abolished by a transverse injection parallel to the masticating surfaces of the teeth half way between the gum-line and reflection of mucosa. The nasal branches are successfully anesthetized by the insertion of a small tampon saturated with 30 per cent. novocain solution upon the floor of the posterior nares. Neglect of these precautions may spoil the most beautiful surgical operation.

In the preparation of abutments or in the excavation of carious dentine the fact is often overlooked that the tooth, though anesthetized, is vital. Overheating or too close encroachment upon the pulp-chamber will lead to painful results and irreparable damage to the pulp. Oral surgeons, who have been used to operating under general anesthesia, had better re-learn how to operate. Speed is absolutely no virtue under conductive anesthesia, the duration of which for from one to three hours is absolutely insured and permits of slow, deliberate and beautiful operations. The manner in which the writer has seen some operators apply their forceps to a tooth or root is enough to frighten the patient forever, and the traumatism caused by speed fiends is not prone to inspire the patient's confidence in conductive anesthesia.

OTHER UNTOWARD RESULTS.

A CERTAIN AMOUNT of after-pain in many operations always will be unavoidable, as it is due to the traumatism caused by the operation itself and from which the tissues have to recover. Proper after-care, however, will successfully overcome this drawback. After thorough iodizing, wounds are dressed with novocain, anesthesin or orthoform powder in substance and tamponed lightly with iodoform gauze. If the edges of the wound are approximated by sutures, tamponing is out of the question, but the application of novocain in powder in bulk upon the fundus of the wound will entirely prevent or greatly minimize postoperative pains. The frequent renewal of dressings is essential and, if the traumatic pain, despite all these measures, should be unbearable, the patient may be carried over the critical stage by injections of 1 per cent. novocain solutions, conductively. The resulting anesthesia greatly heightens the comfort and speed of the healing process. As accessory treatment, ice-bags are applied for from ten to fifteen minutes, or the time-honored Prisnitz cold-water compress protected by a superimposed piece of flannel is employed to reduce inflammation. Violet ray high frequency current also is very soothing and stimulates healing. Internally pyramidon in 5 grain doses is administered to insure relief and a good night's rest.

All other untoward painful results except those just mentioned are best overcome by prevention. Periostitis is avoided by avoiding injury of the periosteum. Pain or impaired function in muscle tissue is caused by perforation of this tissue and deposition of solution within this tissue which acts much in the manner of a foreign body, the absorption of liquids within muscle tissue being extremely slow owing to its poor vascularity. Absorption is hastened by massage and electric

Figs. 16-17-18. Right Mandibular Injection.—The mandibular foramen is located in the internal surface of the ascending ramus, giving entrance to the mandibular nerve into the mandibular canal, innervating the soft tissues facially the bone and pulps of all teeth from the third molar to the central incisor. Owing to anastomosis, if thorough obtunding of first bicuspid to central incisor is desired, the mandibular or mental injection of the opposite side must supplement. The external oblique line is palpated in the mouth and the tip of the index finger held in the retromolar triangle. The needle is inserted at the midlevel of the nail of the palpating finger above the masticating surface of molars; in children and in old age somewhat lower, the barrel of the syringe resting on the bicuspid of the opposite side. The needle is advanced to full length before injecting. If the lingual nerve, innervating the soft tissues lingually is to be obtunded, 0.5 cc. or 1/4 contents of syringe is discharged when the needle has entered the soft tissues halfway. When injecting on the right side the operator stands in front of the patient; when injecting on the left side, the operator stands on the right side, his arm placed around the patient's head, the left index finger palpating the retromolar triangle; or the injection may be made with the left hand, the knack of doing which is readily acquired and, offers easier access to and better visibility of the oral cavity. In either case the patient is seated erect, mouth wide open. Quantity of solution used 2 cc. or one full syringe.

stimulation. Edema is due to overly rapid injections and, if present, should be immediately distributed by gentle massage. Piercing of a blood vessel following unduly rapid advancement of the needle brings about the extravasation of blood into the connective tissues. The resulting clinical symptoms are those of a bruise or black eye with tenderness and the gradual rainbow discoloration of the effused blood. The treatment is the same as that of black eye, all therapeutic measures tending to stimulate absorption by heat and massage. Sometimes an abnormal discolor-

Fig. 19-20. Left Mental Foramen Injection.—The mental foramen is located beneath and between the roots of the first and second bicuspids, where the incisor branch of the mandibular nerve, innervating the bone and pulps of the first bicuspid (sometimes), canine and incisors, also the mental branch, innervating the skin of the chin, skin and mucous membrane of the lower lip, and anastomosing branches of the other side are blocked. Palpate foramen on face with the tip of the index finger, depressing lip with thumb. The needle is inserted in the reflection of the mucous membrane between the two bicuspids and advanced, while injecting almost vertically downward; since the foramen opens distally, until the discharging fluid is felt under palpating finger-tip. Operator stands behind patient, who is erect, mouth half open. Quantity of solution used 1 cc. or ½ syringeful.

ation of the face is noted following infraorbital and tuberosity injections, especially in patients with flabby tissues. The face over the region injected becomes entirely white, color returning after a few minutes. This rather unsightly symptom is no doubt due to the action of the suprarenin upon the veins or the direct introduction into a small vein. Gentle massage will hasten the return of color. Emphysema is due to the introduction of air-bubbles left in the syringe, and, while involving no danger is extremely alarming to the patient and disfiguring. The patient's face is puffed and attempts at aspiration of the air embolus are usually futile, as the embolus changes its position as soon as pressure is brought to bear upon it. Again stimulation of absorption is indicated as a therapeutic measure.

Unduly prolonged anesthesia follows either the accidental injection of alcohol, if the antiseptic solution has not been properly washed from the syringe, or the perforation of the neural sheath. Such surgical injury of a nerve is again best avoided by extreme caution in the insertion of the needle as has been pointed out above. Several cases of anesthesia lasting for weeks and months that have come to the writer's notice, have been due exclusively to a severance of a nerve trunk in the course of an operation, hence cannot be attributed to conductive anesthesia.

Hysterical spasms following several hours after novocain injections can be explained only by preexisting nervous disease which could have been induced by any other irritation of the nervous system, therefore they cannot be directly attributed to novocain.

Erotic symptoms belong to the same class of neurotic disturbances. They are observed far more frequently under general anesthesia, but may be elicited in highly sexed patients merely by the presence or close contact of the operator. Their casual occurrence merely tends to accentu-

Fig. 21. Long Buccal Nerve Injection.—The buccinator nerve, supplying the buccal mucosa of molars and bicuspids and angle of mouth with sensory fibers is blocked as follows: the needle is inserted in the second bicuspid region, half-way between the cervical margin and the reflection of the mucous membrane and is advanced parallel with the masticating surfaces of the molars, while continually injecting on the bony service. Injection in the cheek, opposite the second bicuspid, is indicated if prolonged operation is to be made to avoid pain in the buccinator muscle from holding mouth open a long time. Operator stands in front of patient, who is seated erect, mouth half open. Quantity of solution 1 cc. or ½ syringeful.

ate the necessity of the presence of a third person at any operation, no matter how slight, but especially when anesthetics are given. Erotic hallucinations in hysterics may occur upon seemingly trifling irritation, and it is the operator's duty to guard his patient as well as himself against medico-legal complications.

CONCLUSION.

WHEN WE CONSIDER the thousands of injections of novocain-suprarenin being made in every large community every day without any untoward results whatever, the remarkable safety of this method of anesthesia is patent. Surely few operators would be willing or able to do without conductive anesthesia in their practices today, after they have once come to realize fully its incomparable advantages over older methods. A knowledge of the causes, however, of possible untoward results which may arise seems most desirable, and it is to be hoped that the teaching and practice of this method will be left to the fully competent, else dentistry may again, as it has happened with other methods before, be cheated out of the blessings of a doctrine which has proven itself to be a boon to humanity.

WHILE RESEARCH WORKERS may develop newer methods and expert clinicians may put them into practice, no new method of anesthesia is ever very successful until the way has been shown for teaching it in such a manner that the rank and file of the profession can master it for their routine use. Hence the importance of the emphasis which Theodor Blum of New York City, laid on the teaching of conductive anesthesia, in speaking before the National Dental Association, during its meeting in New York City, October 23-26, 1917. He elaborated his views in a paper published in the Journal of the National Dental Association, July, 1918, and his main points are herewith given for the benefit of those who are interested in teaching the same subject.

NECESSITY OF PRACTICAL COURSES FOR SMALL GROUPS OF STUDENTS WITH INDIVIDUAL INSTRUCTION AND OF PRELIMINARY STUDY OF THE ANATOMY OF THE PARTS INVOLVED.

HAVING TAUGHT Conductive Anesthesia for the past five years, I venture now to write my opinion on this subject.

It was comparatively easy for me to outline a successful plan of teaching because I had personal experience here and abroad in being taught medicine and dentistry by different methods. Among these were not only the old didactic lectures, but also demonstrations and actual work. It did not take long to find out that I profited most, where, after preliminary studies and demonstrations, I was allowed to do the actual practical work on the patient under the personal supervision and instruction of the teacher.

On account of the expense and the lack of a large number of teachers, it is impossible for each student to receive private, individual instruction and, therefore, we have to adopt the next best way, which is, the individual but not private instruction of small groups (which means about six students). In the average case, we have found ten sessions, of about three hours each, sufficient to give such a group a good foundation on which to build up, by further practical experience in their own office, and by study, a satisfactory working knowledge on the subject. Of course this means that they have to study the anatomy involved and the literature before entering the practical course.

DISCUSSION OF ASEPSIS, SOLUTION AND INSTRUMENTS.

IT IS TO MY MIND very important to make each part of the study as simple as possible, and then insist that, while under our supervision, everything is carried out exactly as taught.

The sense of asepsis not being well developed in our profession, I lay especial stress on its observation. We must not overlook to correct the students whenever neglecting this important item. For instance, the dentist is very apt to put his hand on the chair or button his coat, etc., after having scrupulously washed his hands. It seems to be more difficult to have him rid himself of these habits than to make him understand that instruments have to be sterilized, solutions boiled, etc. It would lengthen this paper unduly to give the technic of the preparation of the anesthetizing solution dealt with in previous articles. Suffice to say that the complex array of paraphenalia which has been recommended and invented by some men who appear to have a lot of time and money, have not only scared away a good many earnest men, but are absolutely unnecessary and, through their complexity, dangerous.

I recently read an article in which about half a dozen different needles were recommended. In my experience two needles only are necessary; a long thin steel needle for all injections, except the mandibular, for which a heavier needle is employed. Where iridio-platinum needles are used, one long needle is sufficient. The use of both should be taught, each having its advantages and disadvantages. Nothing new can be said in regard to syringes, a number of new and promising ones being still on test.

DEMONSTRATION OF THE ANATOMY AND ALSO THE TECHNIC OF INJECTIONS ON WET SPECIMENS.

I FIRST RECEIVED the stimulus to study thoroughly the anatomy of the jaws, through an article written by Seidel[1] and then conceived the thought of the importance of using anatomical specimens for teaching purposes. I was encouraged in this work by the ease of instruction (with the help of these specimens) and the comments I heard when demonstrating at the National Dental Meeting in Rochester, 1914.

In my collection there is one head which I have been using for demonstrations ever since I commenced teaching. The head, after being injected by coloring material and hardened in formalin, was then frozen and cut on the right side horizontally 1 cm. above the occlusal surfaces of the lower teeth, the plane of mandibular injection. After cutting through the skull the left temporo-mandibular joint was exarticulated. Now I was able to use the lower half of the specimen for two purposes: the right side was a section (through the plane of mandibular injection) showing all the structures which are of importance; the left side was dissected to give a picture of the course of blood vessels, nerves, etc., through the pterygo-mandibular space, also the osteology of the region, namely, external and internal oblique line retromolar triangle, etc. In the mental region of the same side a window was cut through the skin and the parts prepared to give a clear picture of the mental foramen and the structures passing through it. The left maxilla of the upper half of the specimen was dissected buccally to show the tuberosity and the posterior superior dental nerve in its connection with the main division of the fifth nerve, etc.

In the infraorbital region a flap was cut and the infraorbital foramen, nerves and blood vessels prepared. The palatal side demonstrates the structures in that region. I found it extremely useful and successful to be able, after a thorough demonstration of the anatomical parts, to show first the osteology of the ascending ramus, then the passing of the mandibular needle through the dissected parts on the left side of the specimen and then repeating the technic on the right side by having the needle pass over the section (which means on the level of mandibular injection), while, of course, in both instances the palpating index finger remained in position.

With the help of these specimens the advantages and disadvantages of different methods can be clearly shown and easily understood. For the demonstration of the other injections, the simple preparation of the specimen as outlined above is sufficient for the teaching of beginners. For more advanced students other specimens, especially for the study of mandibular injection,

1. SEIDEL: Die Mandibular anaesthesie. Deutsche Zahnheilkunde in Vortraegen. Heft 28: Leipzig, 1913.

have been prepared at different levels, pictures of which have been published some time ago.

MANAGEMENT OF PATIENTS.

WHILE ONE MAY be even an expert in every phase of the subject, he may fail on account of his lack of ability in the management of patients. The student must watch the instructor very closely in this part of the work. Children, as well as adults, must be treated individually, one rule not being applicable to all patients. An occasional visitor at times may consider us rough or impolite in handling the patients, but longer observation will teach him as well as we were taught by experience that some patients have to be spoken to very politely and patiently, while with others stern and resolute manners must be adopted. To some patients you can explain in detail, if necessary, what will be done, while in other cases again it may be advisable to talk as little as possible without seeming to neglect the interest we have for the patient and the work to be accomplished. It requires experience to read and understand each individual, and we must never lose patience to accomplish our task. Rarely can Conductive Anesthesia not be employed on account of the impossibility of managing the patient.

TEACHING OF PALPATION, INJECTION, ETC., ON THE PATIENT.

THE PRELIMINARY STUDY of the anatomy, the demonstration of same and of the technic of the injection on the wet specimen, make the application of the method on the patient so much simpler and easier. In regard to palpation the student must become familiar with the fact that the best palpation can be accomplished with the index finger only, and that this finger must be employed for this purpose in all injections with the possible occasional exception of the mental. We must learn to palpate gently and carefully without causing the patient the least pain or even discomfort. We must understand palpation is successful only if done lightly, as the different types of tissues cannot be distinguished if the palpating finger rests heavily and presses hard upon the underlying parts. The operator must stand a certain distance away from his patients, so that the neighboring joints, like the wrist and elbow, are not acutely bent but nearly straight and at ease. This is best accomplished by standing in front of the patient, as I believe all operations in Conductive Anesthesia as well as Oral Surgery should be performed. Although nearly every student objects when asked to make certain injections (mandibular, infraorbital) on the left side with the left hand, still they learn very quickly to manage the syringe with that hand and I must say that I cannot see any reason why a dentist who does a good part of his daily work with the left should not make an attempt at it. In fact each one of them ridiculed afterwards his fear that he would not be able to work except with his right hand. I must admit that being naturally left handed and having been forced to use also the right hand, put me in a position where I can use both hands equally well. In that way I found out that a mandibular or infraorbital injection on the left side can be more easily and better accomplished by palpating with the right index finger and injecting with the left hand, especially if we agree that all operations should be performed while standing in front of the patient. The student must remember that when injecting, the solution should be of about body temperature, that the syringe must be gently handled and held in the hand like a probe so that the needle will easily stop at a point of resistance and surely work itself into its proper position without bending or breaking and without injuring the anatomical structures with which it comes in contact.

OTHER ADJUVANTS IN DEMONSTRATING AT THE CHAIR.

A FEW YEARS AGO I discovered, if I am permitted to call it so, an adjuvant for the teaching of mandibular injection which I consider extremely helpful in demonstrating at the chair.

I found, by abducting and extending the thumb from the index finger, a picture is created which wonderfully resembles the structures encountered on the ascending ramus of the mandible. The tendons of the extensor brevis pollicis and extensor longus pollicis form the external and internal oblique lines, while the groove ("snuff-box") between them makes up the retromolar triangle. By following tendon, representing the external oblique line upward, we reach the tip of the thumb forming here the coronoid process, while the circular line from the thumb to the index finger resembles the sigmoid notch. The fingers. We can now explain that the insertion of the needle is made at a point which corresponds to the middle of the disto-buccal root (represented by the second finger) of the second molar and that the needle then proceeds upward and backward over the apices of the buccal roots of the third molar (represented by the third and fourth fingers).

Again, in demonstrating the anatomical position of the mental foramen, we can use the palm

Fig. 1. The back of the hand as used at the chair for demonstrating the ascending ramus of the mandible and the technic of the mandibular injection.

tip of the index finger may be called the condyloid process. The back of the hand corresponds to the inner aspect of the ascending ramus.

The whole technic of mandibular injection can thus be demonstrated at the chair without the anatomical specimen. Each hand can be used to represent the corresponding mandible, and the palpation and demonstration of the injection can be done with the free hand.

In the same way the tuberosity injection can be shown by representing the buccal roots of the second molar with the first and second fingers and of the third molar with the third and fourth of the hand, assuming the lower part of the palm to be the lower border of the mandible, the line connecting the roots of the fingers as the alveolar border and the first and second finger as the first and second bicuspid. Then we can show that, in a vertical direction the mental foramen lies either below the second bicuspid (represented by the second finger) or below and between the two bicuspids (represented by the first and second finger), in a horizontal direction, in the middle between the alveolar border (represented by the line connecting the roots of the finger) and lower border of the mandible (represented by the lower border of the palm of the hand).

One must be in a position to sketch clearly the anatomical structures in their proper relation, so as to be able to demonstrate and explain quickly the points in question without having many different sections and dissections at one's disposal. Most frequently we are called upon to draw the pterygo-mandibular space and containing structures, also the position of the needle during the different stages of the mandibular injection.

LACK OF SUCCESS DUE ONLY TO NEGLECT OF THE ABOVE IMPORTANT PRINCIPLES.

LACK OF SUCCESS in teaching Conductive Anesthesia is practically always the fault of the teacher, who neglects the important principles outlined above. Unfortunately the teaching of this branch as well as other branches in medicine or dentistry is not profitable on account of the time required to instruct properly. To be successful one must have small classes with individual instruction and not only time but also a great deal of patience.

I can frankly say that while teaching is often quite strenuous and tiresome, it always has given, and still gives me, a great deal of pleasure and satisfaction, as we ourselves learn while teaching others.

THERE ARE A NUMBER OF WAYS IN WHICH THOSE WHO ARE VITALLY INTERESTED IN ANESTHESIA MAY ADVANCE THE INTERESTS OF THE SPECIALTY. TO COME INTO ITS OWN THE SPECIALTY MUST FIRST OF ALL BE ORGANIZED ON BROAD LINES THAT WILL PROVIDE FOR LOCAL, REGIONAL AND NATIONAL ASSOCIATIONS. ACTIVE, ENTHUSIASTIC AND CONTINUED MEMBERSHIP IN THESE SEVERAL ASSOCIATIONS IS NECESSARY FOR EACH AND EVERY ANESTHETIST IF HE REALLY HAS AT HEART THE ADVANCEMENT OF HIS SPECIALTY AND THE CONSERVATION OF HIS OWN STATUS AS A SPECIALIST. THEN THE MEETINGS OF THE VARIOUS ASSOCIATIONS DEPEND FOR THEIR ATTRACTION PRINCIPALLY ON GOOD PROGRAMS. IN THIS CONNECTION MANY ANESTHETISTS, WHO ARE MAKING INTERESTING AND VALUABLE RESEARCHES AND CLINICAL OBSERVATIONS, NEVER REPORT THEIR ACTIVITIES AND THEY SHOULD BY ALL MEANS PREPARE PAPERS ABOUT THEIR LATEST ACHIEVEMENTS AND REQUEST AN OPPORTUNITY FOR PRESENTING THEIR CONTRIBUTIONS. NOTHING SUCCEEDS WITHOUT THE INTENSIVE COOPERATION OF ALL CONCERNED. AFTER ALL LEADERS ARE ONLY THOSE WHO ASSUME RESPONSIBILITIES FOR OTHERS AND SHOULDER THE WORK OF PUTTING SOME MOVEMENT ACROSS. BUT THEIR GREATEST EFFORTS COME TO NOTHING UNLESS SUPPORTED BY THE RANK AND FILE.

THE RELATIVE TOXICITY AND EFFICIENCY OF CHLOROFORM, ETHER AND NITROUS OXID-OXYGEN ANESTHESIA IN PREGNANCY AND LABOR . EXPERIMENTAL DETAILS . REVIEW OF MAIN GROUPS OF EXPERIMENTS . CHLOROFORM-AIR . ETHER-AIR . NITROUS OXID-OXYGEN ANESTHESIA AND ANALGESIA . NITROUS OXID-OXYGEN ANESTHESIA, ONE HOUR . CHLOROFORM-OXYGEN, ONE HOUR . DISCUSSION . FACTORS DETERMINING THE CHOICE OF ANESTHETICS IN LABOR . CONCLUSIONS . THE USE OF CHLOROFORM IN THE FIRST STAGES OF LABOR . THE QUESTION OF DELAYED CHLOROFORM POISONING . CLINICAL METHODS AND RESULTS VS. EXPERIMENTAL . CLINICAL OBJECTIONS TO CHLOROFORM . USE OF PITUITRIN . A STUDY OF NITROUS OXID-OXYGEN ANALGESIA AND ANESTHESIA IN NORMAL LABOR AND OPERATIVE OBSTETRICS FROM A SERIES OF 663 CASES . METHOD OF ADMINISTRATION . TECHNICAL POINTS . RESULTS . OPERATIVE OBSTETRICS . ADDITION OF ETHER . CONCLUSIONS FROM THE CASES HANDLED .

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SURGEONS AND ANESTHETISTS are pretty well agreed that the anesthetic should be adapted to the operation and the particular needs of the patient. Naturally there is a marked difference of opinion regarding the choice since all concerned are influenced by their training and the favorable or unfavorable results obtained in individual cases. C. Henry Davis of Chicago, Ill., realizing the confusion of opinion regarding the relative toxicity and efficiency of chloroform, ether and nitrous oxid-oxygen anesthesia in pregnancy and labor, attempted to solve the problem involved, experimentally, in the Department of Obstetrics and Gynecology, Rush Medical College, in affiliation with the University of Chicago and the Presbyterian Hospital. In a paper presented before the American Association of Anesthetists, during the Fifth Annual Meeting, in New York City, June 2, 1917, Davis reported his results and conclusions as follows:

Naturally there is a marked difference of opinion regarding the choice since we are all influenced by our training and the favorable or unfavorable results obtained in individual cases. Statistics would indicate that chloroform is the most dangerous and nitrous oxid-oxygen the safest anesthetic, but one recent writer maintains that nitrous oxid-oxygen is the most dangerous anesthetic, while another states that when given with pure oxygen chloroform is one of the safest. The writer, with many others, has assumed that nitrous oxid-oxygen was the safest anesthetic to use during pregnancy and labor. In his experience there have been no ill effects which could be attributed to the use of the nitrous oxid-oxygen, yet physicians have reported fatalities and other complications which seemed to have resulted from its administration during pregnancy or labor. The reason for this study is therefore evident.

EXPERIMENTAL DETAILS.

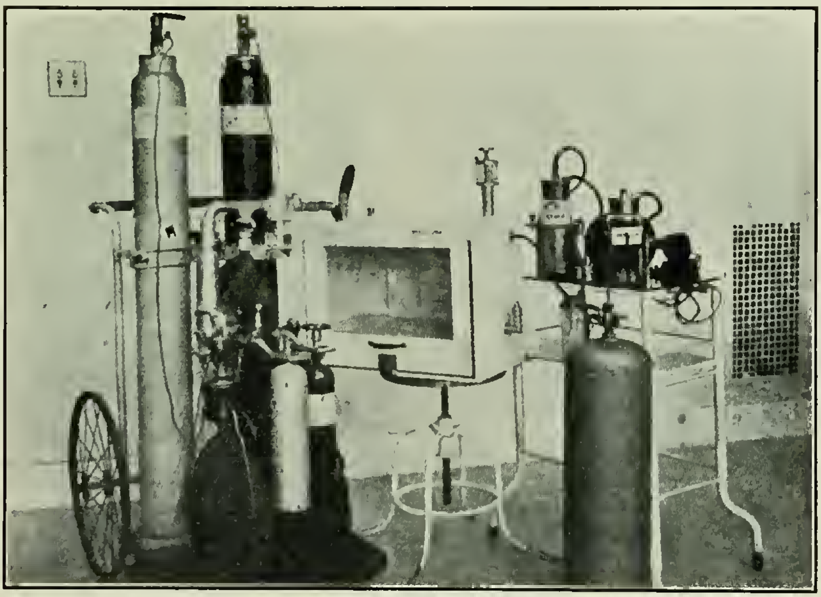
THE LITERATURE SHOWS that a comparison of the former experimental studies of chloroform, ether and nitrous oxid-oxygen is open to much criticism since the anesthetics were administered under very different conditions; without sufficient controls; with the animals in unnatural positions, thereby being subjected to changes from shock, and the quantity of anesthetic used was often excessive for the body weight of the animal. Therefore the writer constructed an anesthetic chamber in which groups of pregnant and non-pregnant animals could be anesthetized under very similar conditions. Each anesthetic was administered in a vaporous or gaseous state. The concentration of carbon dioxid was limited by having a false floor three inches from the bottom of the box under which was placed a solution of lime water or sodium hydrate, and having a ventilating valve near the bottom as well as in the top. The animals had perfect freedom and their condition could be observed at all times through the glass door.

The results of this study were reported in considerable detail to the Chicago Gynecological Society, May 18, 1917.

REVIEW OF MAIN GROUP EXPERIMENTS.

I. CHLOROFORM-AIR.

THREE PREGNANT AND one non-pregnant guinea-pigs were anesthetized two hours daily until they had six hours of light chloroform anesthesia. After the first anesthesia one pig aborted and ate her young. After the third period a second pig aborted three slightly premature young, and died in convulsions twenty-two hours after the end of the anesthetic. The non-pregnant pig died in convulsions twenty-one hours after the end of the anesthetic. Both adult pigs showed typical central necrosis of the liver, marked congestion of the adrenals and edema of the kidney epithelium. The livers of



Experimental Apparatus. Nitrous oxid-oxygen mixing machine with automatic regulators, animal anesthetizing chamber, oxygen tank, and pump used in experiments.

all three young showed a marked passive congestion, cell destruction and fatty changes. The two surviving adults and the one young guinea-pig born alive subsequent to this anesthesia, had a practically normal appearance of tissue when killed five weeks later.

II. ETHER-AIR.

THREE PREGNANT AND one non-pregnant guinea-pigs were anesthetized two second ether pig aborted and ate her young. The third pregnant pig delivered two live young nineteen days after the completion of the anesthetic but these died within forty-eight and seventy-two hours after birth. The livers of the etherized pigs were found to be apparently normal twenty-two days after the anesthesia. The two young which died shortly after birth showed loss in staining power of the liver cells and rather marked fatty changes.

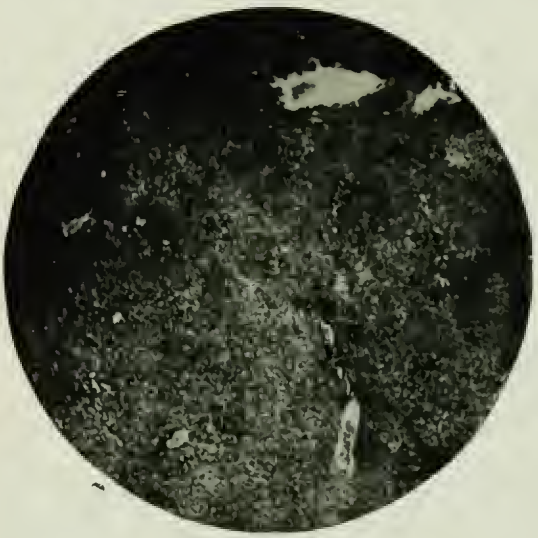


Fig. 1. Extensive central necrosis of liver. Guinea-pig died 22 hours after 6 hours of light chloroform anesthesia. Photomicrograph x62.

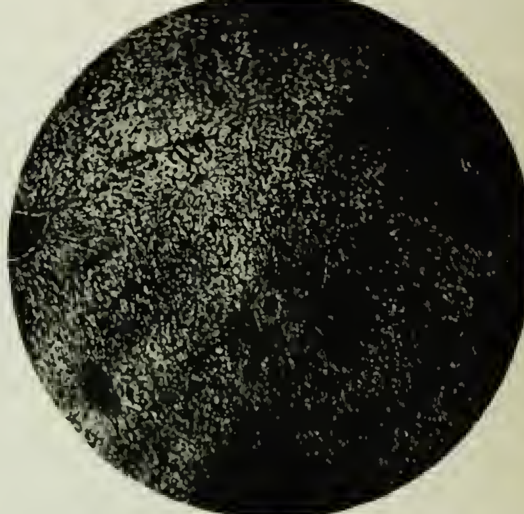


Fig. 2. Marked congestion of the liver of a fetus still-born, after mother had two hours of light chloroform anesthesia. Photomicrograph x62.

hours daily for two days and three hours and fifteen minutes the third period. After the first anesthetic one gave birth to two live young which were anesthetized with their mother the remaining five hours and fifteen minutes. The non-pregnant pig, one of the young, and a normal control animal were anesthetized and killed by decapitation forty-eight hours after the last anesthesia. The livers of these animals showed some loss of staining power and presented a picture resembling that seen after ordinary asphyxiation. This is thought to be a moderate degree of parenchymatous degeneration and tissue swelling. The young pig had evidence of some fatty changes and cell edema. Its mate killed twenty days later had an apparently normal liver. The

The liver changes found after ether anesthesia are of a different type and less severe than those observed following chloroform.

III. NITROUS OXID-OXYGEN ANESTHESIA.

THREE PREGNANT AND two non-pregnant guinea-pigs were anesthetized daily for four days until they had a total of seven hours and forty-five minutes of nitrous oxid-oxygen anesthesia. At the end of this period one of the pigs died under an anesthesia from which the others recovered within two minutes after being removed from the box. The sections of its liver showed a pathological condition as evidenced by a marked round cell infiltration. Another pig died of tuberculosis and peritonitis twenty-two days later. It contained macerated young. A third pig which aborted died of pneumonia thirty-two days after the anesthesia. In this experiment all of the young apparently died in utero. The non-pregnant pigs were killed with nitrous oxid asphyxia two months after the anesthesia. The marked peritoneal hemorrhage from the liver of one, and the evidence of bloody serum on the capsule of the liver of both suggests that they had not completely recovered from its ef-

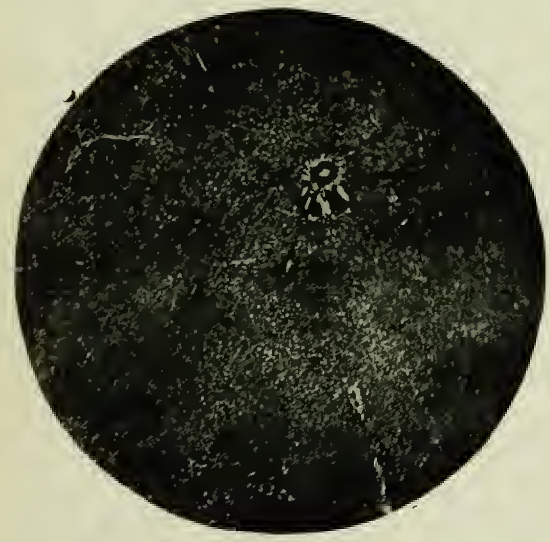


Fig. 3. Liver of young guinea-pig born alive 16 days after 1 hour of light chloroform anesthesia, given with an excess of pure oxygen. Note fatty vacuoles. Photomicrograph x62.

fects. A control pig killed at the same time had a marked passive congestion of the liver but no macroscopic hemorrhage from its capsule.

IV. NITROUS OXID-OXYGEN ANALGESIA.

THREE PREGNANT AND one non-pregnant guinea-pigs were placed in the box and given a mixture containing from 20 to 30 per cent. oxygen two hours daily for three days. One of the pigs delivered one live young just before the second period and delivered the second while in the box. This young pig lived its first half hour in the mixture. Before the third period a second pig delivered three live young. The four adults and five young pigs were placed in the box for the third period. The remaining pregnant pig aborted the night following the third analgesia. The pig born in the box was found dead the morning after the last period. Twenty-four hours later two more of the young were found dead. Two days later one of the mothers died of peritonitis and forty-eight hours after her death her remaining young died of pneumonia. The still-born young had a marked round cell infiltration of the liver. The pigs dying forty-eight hours after the completion of the

Fig. 4. Sudan III stain of frozen section of tissue shown in Fig. 3. Photomicrograph x62.

analgesia had a passive congestion of the liver, and moderate fatty changes. Those living six days had normal appearing liver tissue. The livers of the adult pigs seemed to be very little affected by the analgesia and appeared normal when killed.

V. NITROUS OXID-OXYGEN ANESTHESIA, ONE HOUR.

TWO PREGNANT AND one non-pregnant guinea-pigs were given one hour deep nitrous oxid-oxygen anesthesia. The non-pregnant pig was killed by decapitation fifteen minutes after the completion of the anesthesia. Its tissues appeared perfectly normal. One of the pregnant pigs delivered four still-born young seven days after the anesthesia. The other delivered three premature live and two still-born young thirteen days after the anesthesia. The three young died within a few hours after birth and their livers show the round cell infiltration previosuly observed in still-born animals. The tissues of the mothers appear normal.

It should be noted that with guinea-pigs the larger the litter the smaller the young and the greater the mortality following birth.

Various controls were made by killing normal animals with nitrous oxid asphyxia, ordinary asphyxia, etherizing and killing by decapitation, holding and decapitating, asphyxiating with nitrous oxid until respiration had stopped then removing and resuscitating. Sections of liver, lung, heart, adrenals, kidneys and spleen were made from fifty animals. Evidence of hemorrhage from the liver was found after both chloroform

Fig. 5. Liver of normal guinea-pig asphyxiated in bell-jar. Note evidence of congestion and loss in staining power of cells. Photomicrograph x62.

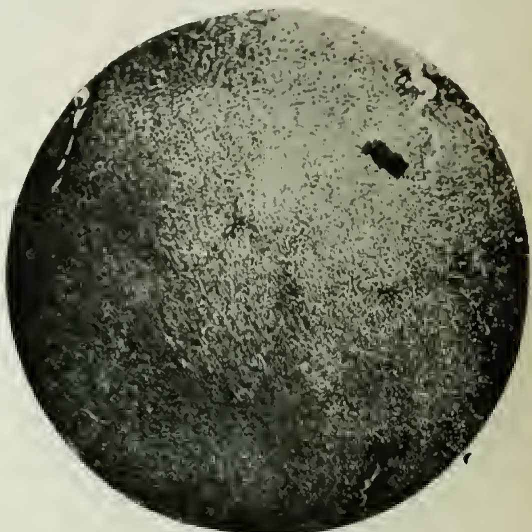


Fig. 6. Liver of guinea-pig killed by decapitation 24 days after 7 hours and 15 minutes of ether anesthesia. Photomicrograph x62.

and nitrous oxid. None was observed after ether anesthesia.

VI. CHLOROFORM-OXYGEN, ONE HOUR.

TWO PREGNANT AND one non-pregnant guinea-pigs were lightly anesthetized with chloroform, forty gallons of oxygen being passed into the box during the hour of anesthesia. The non-pregnant pig was killed forty-eight hours after the completion of the anesthesia and was found to have a liver which is microscopically normal. The pregnant pigs delivered one and two young respectively sixteen days later. These were killed with their mothers by decapitation forty-eight hours after birth. One of the mothers had yellow areas on the surface of the liver which were found to be fatty. All three of the young had very yellow livers and the sections show that they had a large amount of fat. This is seen in the Sudan III stains of frozen sections.

DISCUSSION.

IN THE PRESENT PAPER the writer wishes to call attention to a number of points reported in the literature which support the conclusions which he has reached from his experimental and clinical study of chloroform, ether and nitrous oxid-oxygen. He realizes that his results are not conclusive but offers them with the hope that they will stimulate further and more careful studies both clinical and experimental.

The work of Graham, Sansum, Woodyatt and others indicates that "Chloroform is prone to cause swelling of cells, with fat infiltration, necrosis, and a hemorrhagic tendency. Ether has not been observed to cause necrosis, but it may produce milder form of parenchymatous degeneration and tissue swelling. Nitrous oxid has little tendency to produce any visible tissue changes. The tendency of chloroform, ether, and nitrous oxid to produce suppressions of glucose and nitrogen excretion on phlorizinized dogs parallels their ability to produce changes in which tissue swelling is an important feature. Working with chloroform it is difficult to narcotize phlorizinized dogs for more than 8 to 10 minutes without killing them; although with ether, narcosis was successfully prolonged for two hours." (Sansum and Woodyatt.)

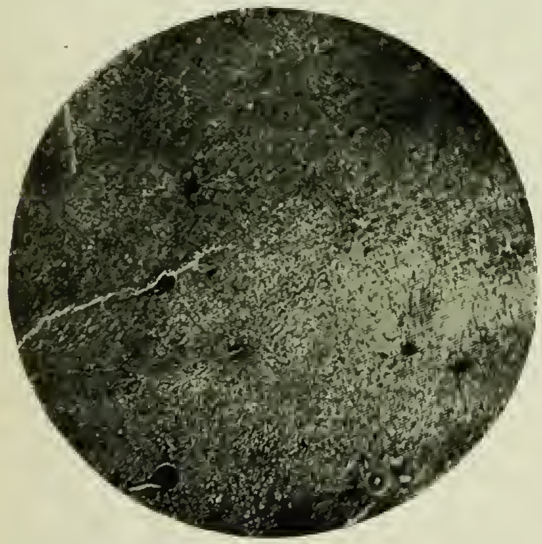


Fig. 7. Liver of normal guinea-pig killed by nitrous oxid asphyxiation. Tissue very similar to that of Fig. 5. Photomicrograph x62.

It has long been recognized that a glycosuria may follow a deep anesthesia. The experiments of King, Chaffee, Anderson, Redelings and others show that when given to healthy animals in sufficient doses, narcotic drugs cause a hyperglycemia with or without a glycosuria, that the rise in blood sugar is at the expense of glycogen, and that this is caused by cell asphyxia. Bradner and Reimann found acetonuria in 61.7 per cent. of Deaver's postoperative cases.

Cases of late chloroform poisoning give clinical confirmation to the laboratory production of the central liver necrosis following the administration of chloroform to healthy animals. The present experiments offer some evidence to disprove Gwathmey's belief that chloroform vapor is made safe by administering it with pure oxygen.

Apart from the possibility of the late poisoning, chloroform may be the exciting cause of death in course of an anesthesia. Levy (see Year-Book, 1915-16), from his valuable clinical and experimental study states that: Death from ventricular fibrilations under chloroform may be observed under any of the following and allied conditions.

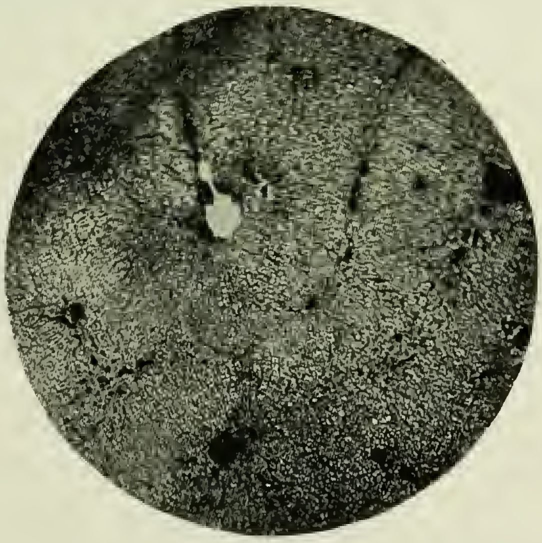


Fig. 8. Note the marked engorgement of liver in guinea-pig killed by nitrous oxid asphyxia 2 months after 7 hours and 45 minutes of nitrous oxid-oxygen anesthesia. Compare with Figs. 5 and 7. Photomicrograph x62.

A. During the induction and early stages of the administration of chloroform and exceptionally late in the administration: (1) during struggling and excitement; (2) on removal of the chloroform; (3) on abrupt administration of the chloroform after removal or its sudden increase during a period of very light anesthesia, and (4) by any combination of these occurrences.

B. During operation. By strong sensory stimuli under light anesthesia.

C. After operation. On removal of the chloroform, especially after a short operation.

There can no doubt that all anesthetics cause changes in the blood. Casto (see Year-Book, 1915-16), in this report on this subject says: "The bibliographic review of this subject would indicate that hemoglobin is always reduced under anesthesia, by chloroform, ether or nitrous oxid-oxygen. Hemoglobin is markedly reduced under ether, and the greatest reduction in pigment is at the end of twenty-four hours, after which there is a gradual return to the normal in about one hundred hours. Under nitrous oxid-oxygen anesthesia the reduction is not only slight, but the return to normal occurs in two to three hours. * * * Hemolysis is observed under chloroform and ether, but no degenerated or crenated cells have been found."

Fig. 9. Liver of young guinea-pig born 23 days after 7 hours and 15 minutes of ether anesthesia and dying within 48 hours after birth. Photomicrograph x62.

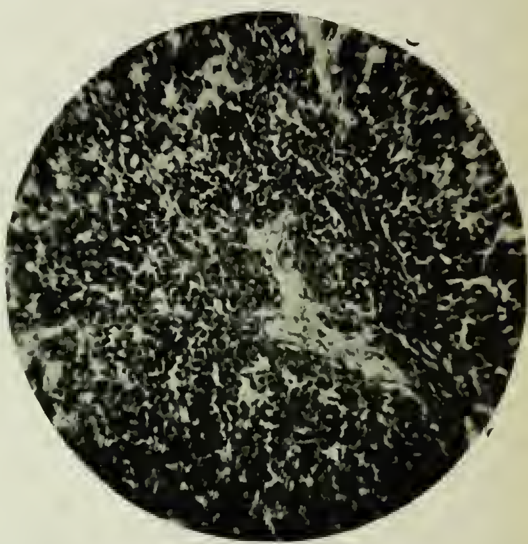


Fig. 10. The marked round cell infiltration is an indication of the primary pathology in a pregnant guinea-pig dying just before the completion of 7 hours and 45 minutes of nitrous oxid-oxygen anesthesia. Photomicrograph x288.

Casto states further that: "The acid production of metabolism may be increased under deep anesthesia when cyanosis is permitted to occur or continue; but when a sufficient supply of oxygen is provided, this may be prevented." Yet from the experiments of others it is apparent that some cell asphyxia must result from interference with normal metabolism, regardless of the amount of oxygen in the blood.

The reports of the various writers all indicate that chloroform is the most dangerous inhalation anesthetic. While their statements may not indicate the relative clinical value of ether and nitrous oxid-oxygen, they show that the changes in the adult following the administration of ether are more permanent than those resulting from nitrous oxid-oxygen. Some observations in the present experiments suggest that the cell injury following the use of any of these anesthetics may persist for a longer period than was formerly thought possible, and leads the writer to believe that the anesthetic may be an important factor in some of the more remote postoperative complications as well as the immediate.

There is little or no experimental evidence to suggest a normal individual would die from the proper use of any of these anesthetics during the period of an ordinary operation. It seems probable that sudden deaths under ether or nitrous oxid-oxygen may result from conditions closely akin to those observed by Levy during the use of chloroform. The term, *anesthetic death*, as now used by many surgeons merely indicates that the patient died under the anesthetic, and therefore means nothing. Every surgeon should be a skilled anesthetist, and every anesthetist should have experience as a surgical assistant. Were this the case surgeons would be less prone to blame their errors in judgment on the anesthetist, and the anesthetist could better cooperate with the surgeon.

The choice of an anesthetic during pregnancy and labor involves a consideration of the fetus as well as the mother. The present experiments suggest that in considering only the dangers to the mother we may have been adding to those involving the fetus. They show that the fetus is more susceptible to chloroform poisoning than the mother, and that the long continued administration of nitrous oxid-oxygen anesthesia may asphyxiate the fetus in utero without seriously endangering the life of the mother. The danger to the fetus from nitrous oxid is apparently not completely removed by adding oxygen in the percentage found in air. Ether anesthesia seems to be better borne by the fetus in utero and the very young than is chloroform or nitrous oxid-oxygen. Therefore these experiments would suggest that ether, unless contraindicated is the inhalation anesthetic of choice for operations during pregnancy.

FACTORS DETERMINING THE CHOICE OF ANESTHETICS IN LABOR.

DURING LABOR MANY FACTORS must be considered in the choice of the anesthetic. Pain does not begin with the first evidence of the uterine contraction but at or near its height. Once pain is established little can be done to relieve the suffering from that contraction. Therefore the value of an anesthetic depends upon the quick induction of analgesia at the very beginning of a contraction. For this purpose chloroform vapor and nitrous oxid-oxygen gas are equally effective. The quick administration of ether vapor gives a considerable relief in many cases but it is less efficient than the others. However, both chloroform and ether tend to lessen the strength of the uterine contractions; they are eliminated slowly and gradually accumulate in the system; and babies born under these anesthetics may have the anesthetic in their systems for many hours after birth.

Nitrous oxid-oxygen as used in normal labor, given only during the first few inhalations at the beginning of a contraction, is very efficient and undoubtedly the safest anesthetic that has been employed. It seems probable that the fetus can absorb very little of the anesthetic during the contraction, and nitrous oxid is so quickly eliminated that very little will remain in the maternal blood at the end. Therefore, there is not the cumulative tendency of chloroform or ether, and the normal metabolism of the fetus is not disturbed during the interval between contractions.

CONCLUSIONS.

THE FOLLOWING SUGGESTIONS are offered in conclusion:

1. Chloroform, regardless of the technic employed and the amount of oxygen supplied, is the most dangerous anesthetic to both mother and fetus.

2. Nitrous oxid-oxygen anesthesia interferes with the oxygen supply of the fetus in utero and if given over a considerable period may cause its death. There is probably very little danger to the fetus during an examination or short operation if the nitrous oxid-oxygen is administered skilfully without cyanosis.

3. The continuous nitrous oxid-oxygen analgesia while less dangerous to the fetus than the anesthesia, should not be administered over long periods.

4. Ether, unless otherwise contraindicated, is the anesthetic of choice for operations during pregnancy or labor.

5. Nitrous oxid-oxygen administered intermittently at the very beginning of the contractions is the analgesic of choice for normal labor. When this is not available, ether, though less efficient, may be administered in a similar manner at a minimum of expense.

6. The term *anesthetic death* as often used means nothing.

7. There are no statistics which would indicate that the use of anesthetics to lessen the pain of labor has *per se*, increased either fetal or maternal mortality.

OWING TO THE DIVERGENT OPINIONS of the pathologists and clinicians regarding the safety of chloroform in the first stages of labor, Isador Hill of New York City and his co-workers in the Pathological Laboratory of the College of Physicians and Surgeons, attempted experimentally to imitate the narcosis of childbirth and determine the results. The data developed were presented to the Section on Obstetrics, Gynecology and Abdominal Surgery of the A. M. A., during the Detroit Meeting, June, 1916.

In the world at large, in hospitals and private practice, both in town and in the country, writes Hill, chloroform is still the anesthetic most largely used in obstetrics. It has survived many eras of criticism. In Simpson's[1] early exploitation of it some of the objections encountered were the alleged production of epilepsy, insanity and septicemia and the pious belief that it was sacrilegious to remove the sorrows of childbirth.

Later, when deaths were found to be more frequent from chloroform than from ether in surgical anesthesia, its use in obstetrics was criticized. But chloroform accidents in midwifery were almost unknown. On its own merits it prevailed again on the evidence of experience, and theories were advanced to explain an apparent special immunity in labor.

At present we are in a period of active criticism of its use because of late chloroform poisoning with degeneration of the liver and other organs.

At an obstetric meeting a few years ago, a pathologist in discussion[2] said that chloroform was shown to have toxic effects and that in its use obstetricians were the worst offenders.

An obstetrician of wide experience in reply said that he had never seen harmful results[3] from chloroform in labor and did not believe its use was dangerous.

This expression of divergent opinions by the pathologist and the clinical observer represents fairly well the present status of this narcosis in midwifery. Very recently a tendency is shown on the part of the obstetricians to yield their position based on experience to the findings of the experimentalists. We find some hospitals have given up the use of chloroform entirely because of its late toxic effects.[4] Current medical literature shows little or nothing written in favor of chloroform in obstetrics, yet its use continues. It is time to rehabilitate or abandon it. We cannot go on with the surreptitious use of this narcosis as if it were a secret vice.

THE QUESTION OF DELAYED CHLOROFORM POISONING.

TO ASK THE abandonment of so widely used a drug we should expect pathologic evidence proportionate to its exhibition. Chloroform has been used in labor millions of times. We could reasonably expect some worker to gather statistics showing results of some hundred necropsies in women dying from its use in normal childbirth.

H. Roulland[5] in 1910, gathered a series of reported cases of late chloroform poisoning. Among them was one by Fraenkel[6] in 1892, of a woman dying twenty days after labor with fatty degeneration of kidneys and heart. The liver was not mentioned in Fraenkel's article. There was thrombosis of the large pelvic veins and death occurred suddenly from pulmonary embolism.

In the other cases assembled by Roulland from

1. Simpson, J. Y.: Account of a New Anesthetic, 1847.
2. Ewing: Tr. Wash. Obst. Soc., Am. Jour. Obst., 1910, Vol. lxi, 516.
3. Bovee: Tr. Wash. Obst. Soc., Am. Jour. Obst., 1910, Vol. lxi, 516.
4. Rongy: Am. Jour. Obst., 1914, Vol. lxx, 636.
5. Roulland, H.: Gynécologie, 1910, Vol. xiv, 26.
6. Fraenkel: Virchows Arch. f. path. Anat., 1892, Vol. cxxvii, 381.

the time of Casper[7] and Langenbeck,[8] from 1850 to 1910, the date of his article, the deaths (less than twenty) were found to follow surgical anesthesia in operations for various diseases, including suppurations of long standing.

Von Braeckel[9] reports two cases in surgical anesthesia and ascribes the liver damage to deficient glycogen.

Moran[10] reported a delayed chloroform death after labor, but the patient had previously had nephritis and had been on a restricted diet.

A careful search of medical literature does not seem to reveal the elements for a series of cases of late chloroform poisoning in obstetrics.

Meanwhile we can find the testimony of countless obstetricians whose cases combined aggregate hundreds of thousands, to the effect that they have never seen injurious results following chloroform in labor. These men have not been unmindful, but have been warned to be watchful for this sequel; for it has been frequently called to the attention of the profession at large for over sixty years.

After the report of the Hyderabad Chloroform Commission[11] a controversy raged, in which apparently everything that could be said about chloroform was published. Lawrie[12] showed a series of 45,000 chloroform anesthesias without a death. Patrick Hehir[13] reported giving chloroform continuously for over twelve hours in three cases of eclampsia, with recovery. Although every unfavorable narcosis event in contemporary medicine was also brought to light, it is noteworthy that no untoward occurrence was mentioned concerning chloroform in labor.

More recently Eisenberg[14] reported no late injurious effects even in prolonged obstetric chloroform anesthesias and advocated its extensive employment in labor.[15]

Leading obstetricians and practitioners of wide experience, such as Georghi,[16] Engel,[17] Veit,[18] Tissier,[19] Müller,[20] Flammer[21] and Buxton,[22] all bear favorable testimony based on extensive clinical material.

With the overwhelming clinical evidence of safety on the one hand and the scant pathologic findings on the other, it is apparent that some other factor must have caused the obstetricians to distrust their time-honored anesthetic. This has arisen from animal experimentation.

The earlier work of Nothnagel,[23] Thiem and Fischer[24] and others does not seem to have had much influence on clinicians. We begin to see a certain reflection in obstetric journals from the observations of Doyen and Billet[25] and particularly of John Howland and A. N. Richards,[26] who made numerous experiments in chloroforming animals, revealing subsequent changes in the liver and kidneys. Whipple and Sperry[27] did similar work. Fischler[28], produced the lesions but ascribed only an indirect influence to chloroform. Clark[29] showed that pregnant animals have no special immunity to chloroform poisoning.

7. Casper: Casper's Wchnschr., 1850.
8. Langenbeck: Quoting from Berend's Chloroform Casuistik, 1850.
9. Von Braeckel: Samml. klin. Vortr., 1913, No. 674.
10. Moran: Tr. Wash. Obst. Soc., Am. Jour. Obst., 1910, lxi, 512.
11. Lancet, London, 1890, Vol. i, 149.
12. Lawrie: Lancet, London, 1890, Vol. i, 174.
13. Hehir, Patrick: Med. Chronicle, June, 1891, Vol. xiv, 179.
14. Eisenberg: Wien. klin. Wchnschr., 1910, Vol. xxx, 209.
15. Eisenberg: Zentralbl. f. Gynäk., 1910, Vol. xxxiv, 689.
16. Georghi: Zentralbl. f. Gynäk., 1910, Vol. xxxiv, 888.
17. Engel: Zentralbl. f. Gynäk., 1909, Vol. xxxiii, 496.
18. Veit: Therap. Monatsh., December, 1908.
19. Tissier: Zentralbl. f. Gynäk., 1909, Vol. xxi, 54.
20. Muller: Zentralbl. f. Gynäk., 1906, Vol. xxx, 502.
21. Flammer: La narcose theorie et pratique, Paris, 1913, p. 221.
22. Buxton: Anesthetics, Their Use and Administration, Ed. 5, Philadelphia, 1914.
23. Nothnagel: Berl. klin. Wchnschr., 1866, Vol. iii, p. 111, p. 31, p. 367,
24. Thiem and Fischer: Deutsch. med. Ztg., 1889, p. 1111.
25. Doyen and Billet: Jour. de phys. et de path. gén., 1905, Vol. vii, 639.
26. Howland, John, and Richards, A. N.: Jour. Exper. Med., 1909, Vol. xi, 344.
27. Whipple and Sperry: Bull. Johns Hopkins Hosp., 1909, Vol. xx, 278.
28. Fischler: Mitt. a d. Grenzgeb. d. Med. u. Chir., 1913, Vol. xxvi, 553.
29. Clark: Glasgow Med. Jour., 1914, Vol. lxxxi, 33.

Donzelli,[30] Delbert, Herrenschmidt and Beauvy,[31] C. Oliva,[32] G. S. Graham[33] and others have made a special study of changes in the suprarenals.

Evarts Graham,[34] (see Year-Book, 1915-16), in a particularly convincing work, has produced necrosis in guinea-pigs and dogs, and has shown that the damage takes place through the liberation of hydrochloric acid. He has found that when alkalies are simultaneously administered the destructive effects of chloroform are inhibited.

Most of the experimentalists who have shown changes in the organs have called attention to the extremely rapid and complete regeneration which takes place, the tissues appearing normal in a few days.

Lengeman[35] found that by using a special apparatus which permitted the administration of the minimum of diluted chloroform vapor necessary to keep dogs in anesthesia he did not usually succeed in producing the changes in the liver which had been found by others. In how far is this experimental work applicable to practical obstetrics?

CLINICAL METHODS AND RESULTS VS. EXPERIMENTAL.

IT OCCURRED TO ME that full surgical anesthesia, more or less prolonged and often repeated on successive days, as done by the experimentalists who report these findings, does not represent the narcosis commonly used in obstetrics.

I determined to give chloroform to animals in a manner imitating its administration in obstetrics and watch the results. Dogs and guinea-pigs were anesthetized in the following manner:

30. Donzelli: Arch. di farmacologia sper., 1911, Vol. xi, 51.
31. Delbert, Herrenschmidt and Beauvy: Rev. de chir., 1912, Vol. xlv, 544.
32. Oliva, C.: Tr. Int. Cong. Med., 1913, Subsection 7, B, Part 2, p. 167.
33. Graham, G. S.: Jour. Med. Research, 1916, Vol. xxxiv, 241.
34. Graham, Evarts: Jour. Exper. Med., 1915, Vol. xxii, 48.
35. Lengeman: Beitr. z. klin. Chir., 1900, Vol. xxvii, 805.

The animal was strapped to a board and given chloroform[36] from a mask for thirty seconds (the period representing a labor pain). This was repeated every four minutes for two hours, every three minutes for one hour, every two minutes for one hour and then the animal was continuously anesthetized for a half hour. Some of the animals received the anesthetic for one hour less than that and the complete final anesthesia was omitted.

The animals were killed at intervals of two, four and six days and the livers examined. Contrary to my expectation, the same changes in the liver were found as described by Howland, Graham and others, as well as the same tendency to rapid regeneration.

The study of these experiments, however, seemed to furnish the key to the mystery. It explained how women may be given chloroform in labor and never show symptoms or come to necropsy while dogs and guinea-pigs certainly suffer pathologic changes, at least temporarily.

Although planned theoretically to imitate the narcosis of childbirth, my anesthetization of these animals did not in fact resemble it at all. The animals were strapped to boards, where they strained for a considerable period until finally they became drowsy from exhaustion or somnolent from the effect of the anesthetic. One 15-pound dog was given at times 25 drops at a dose on a closely fitting mask to obtain some semblance of quietude. There was no euphoria in these animals.

A woman in labor has suffered pains and fears their return. She believes chloroform will give relief. She receives an adequate inhalation during a pain. This is repeated with other pains. She anticipates relief from chloroform. All the forces of suggestion are at work. The wonderful relief from small doses is due in a small part to its analgesic effect, in much larger part to a sort of hypnotism.

36. These experiments were performed in the laboratory of Dr. Seymour Oppenheimer and in the Pathological Laboratory of the College of Physicians and Surgeons of New York. The sections were prepared and studied by Dr. Mark Gottlieb.

Case 1.—Mrs. M., tripara, weight 155 pounds, was exceedingly nervous and hyperesthetic. There were slight pains beginning 3 a. m., which became regular and hard at 5 a. m. Cervix three fingers. Suffering intensely. Began chloroform at 5:07, 7 drops on mask applied for thirty seconds. Pains every two minutes. Seven drops of chloroform with each pain. Patient in perfect analgesia. Pituitary extract ½ ampule given. Eleven more pains up to 5:48. Pituitary extract ½ ampule given. Five more pains up to 6:05, when patient was delivered Fifteen drops instead of 7 at each pain for each of last three expulsive pains. Weight of child, 8 pounds 4 ounces. Total chloroform 185 drops.

Guinea-pig No. 1 in my series weighing ½ pound received 112 drops of chloroform on a more closely fitting mask in its theoretical analgesia.

Case 2.—Mrs. H., primipara, aged 32, weight 138 pounds. Labor began 6 a. m. Examined 9 a. m., external os 1 finger, cervix 2 cm. long. Head at brim, left occipito-anterior presentation, pains every four minutes, lasting fifteen seconds. Weak contractions, no suffering. Membranes ruptured spontaneously at 11:10. Pains irregular, short, intensely painful. Practically no increase in dilatation. Patient neurotic, became hysterical. Chloroform with each pain beginning 11:50 Pituitary extract ½ ampule. Contractions improved, patient in agreeable analgesia. Pituitary extract ½ ampule repeated every twenty-five minutes. Chloroform continued 5 to 10 drops at each pain. Contractions lasted from thirty to forty seconds, but chloroform mask held to face only during height of pain, usually twenty seconds. At 2:05 dilatation complete, pains every two minutes. Strong contractions, well sustained. Pains more powerful, intermission one minute. At 2:45 head on perineum. Full anesthesia. Delivered at 2:57. Placenta 3:05. Total pituitary extract 4 ampules. Total chloroform 500 drops.

Dog No. 2 in my experiment, weight 15¾ pounds, received 635 drops of chloroform. Struggling and howling except during last forty minutes of three hour narcosis.

I am convinced that there is no parallel in the giving of small doses of chloroform during labor pains to a woman and the experimental anesthesias of animals on which the condemnation of chloroform is based.

The legitimacy of applying to the human subject the results produced in laboratory animals has often been contested. There is a great variation in susceptibility to given poisons and toxins among different kinds of animals. It may be assumed that human beings may differ from other animals in susceptibility to poisoning by this drug.

Certainly the large doses of chloroform in proportion to the weight given to a fear-exhausted animal are not comparable with the whiffs of chloroform given to a healthy woman in a cheerful and receptive frame of mind.

I have never seen any symptoms due to this narcosis, the so-called chloroform *à la reine,* and am inclined to take a position based on the evidence of the numerous competent clinical observers who have reported favorably on it from their actual experience.

If we are reluctant to ignore the effects shown in animal experiments, we can accept the findings of the recent work of Evarts Graham.[34] He has shown that alkalies administered along with chloroform inhibit its toxic effects on animals. If we are giving a protracted anesthesia, we can give alkalies.

The experiments of Marshall and Rowntree[37] and others showing decreased fibrinogen in the blood of animals from chloroform anesthesia are open to the same objection as the other experimental findings as having no proved application to human beings.

CLINICAL OBJECTIONS TO CHLOROFORM.

THERE HAVE BEEN OBJECTIONS to the use of chloroform in the second stage of labor on the ground that it weakens contractions and delays progress. For the same reasons it is practically forbidden during the first stage of labor by most textbook writers.

There are many cases, however, in which chloroform greatly shortens labor by relieving suffering and encouraging voluntary expulsive efforts in the second stage. Every accoucheur has seen patients who were making no progress, suddenly delivered with the administration of chloroform, while preparations were under way for forceps extraction.

A number of authorities, among them Galabin[38] and Eisenberg [14] approve of chloroform for certain cases in the first stage. Newell[39] recom-

37. MARSHALL and ROWNTREE: Jour. Exper. Med., 1915, Vol. xxii, 333.

38. GALABIN and BLACKER: The Practice of Midwifery, New York, The Macmillan Company, 1910, p. 315.

39. NEWELL: Surg., Gynec. and Obst., 1906, Vol. iii, 126.

mended anesthesia in the first stage for various indications but used ether.

In 1855 Edward William Murphy[40] wrote of chloroform as follows:

> There is one condition of the cervix uteri in which I have given it with great advantage in the first stage of labor. The neck of the womb is sometimes caught and greatly compressed between the head and pelvis. The pain is excruciating and the action of the uterus is often deranged or suspended, the woman cannot endure her agony and her strong apprehensions interrupt the pains. Let her have chloroform and she becomes tranquil, the action of the uterus returns regularly and the dilation is soon completed. Under such circumstances I have given chloroform when the mouth of the womb was not opened more than a sixpence and was gratified to find the dilatation advance more rapidly.

USE OF PITUITRIN.

IN MY EXPERIENCE practically all objections to chloroform on the ground of delaying contractions have disappeared since I have been using pituitary extract.

Bandler[41] reports that more pituitary extract is necessary when chloroform is used. There need be no objection on that ground. A small percentage of each agent may be neutralized by the other. At all events using ½ ampule of pituitary extract every twenty-five minutes during the administration of chloroform in small doses at each pain I find that labor progresses rapidly.

In fact the labor is so short that the total period during which chloroform need be given must relieve the anxiety of those who fear its use.

Many patients, particularly multiparas, do not need an anesthetic at any time during labor. Some require it only at the final expulsion. But there must be no arbitrary rule as to when it should be begun. The time to administer chloroform is not at two hours or at fifteen minutes before the expected end of labor. It is when the patient begins to be unequal to the suffering. Hold the morale of the patient. Keep the pain within the limits of her fortitude. Have her inspired with her efforts and assured of your assistance if the suffering is too great. She will not be the worse for such consciousness of pain as she has borne easily and willingly. She will not regret amnesia, but will remember with satisfaction her share in the victory. A very little chloroform in the early periods of labor will be sufficient to control the patient and secure her tranquil cooperation. It is a fortunate circumstance that the neurotic women, who are most likely to need early analgesia, are also most amenable to suggestion and on small doses are brought into the semihypnotic state.[42]

It is not within the scope of this paper to make a comparison between chloroform and various other agents. Ether, nitrous oxid alone, nitrous oxid and oxygen, and scopolamin and morphin all have adherents. Some of these narcoses have just begun to arouse interest. Others have attained a great popularity which is already subsiding.

My purpose has been to seek reassurance for the many who find chloroform satisfactory. I wish to emphasize the fact that chloroform in normal childbirth produces a distinct anesthesia in which its effects are strengthened and supplemented by the influence of suggestion.

The use of pituitary extract with chloroform by greatly shortening the labor further restricts the dosage of the anesthetic and modifies the rôle played heretofore by chloroform in labor cases.

The question of remote poisoning is not new, but has been before the profession for more than half a century. Late developments in labor cases in which chloroform was used have necessarily been watched by many competent obstetricians, yet there is practically no incontestable evidence of late poisoning in normal women in labor.

There is no parallel between animal experimentation on which the late toxic effect of chloroform is alleged and its use in normal obstetrics.

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40. MURPHY, WALTON and MABERLY: Chloroform in Childbirth, London, 1855.
41. BANDLER: Am. Jour. Obst., 1916, Vol. lxxiii, 77.
42. HALLAUER: Deutsch. med. Wchnschr., 1910, Vol. xxxvi, 263.

W. C. DANFORTH—NITROUS OXID IN LABOR AND OPERATIVE OBSTETRICS

THE INITIAL EXPERIENCES of W. C. DANFORTH of Evanston, Ill., with nitrous oxid-oxygen analgesia in normal labor and operative obstetrics, were so encouraging that the method has been established as a routine in the Obstetrical Department of Evanston Hospital. Supplementing his original report in the American Journal of Obstetrics, October, 1917, Danforth presented his further experiences before the American Association of Anesthetists, during the Sixth Annual Meeting, at Chicago, June 10-11, 1918, which were published, as follows, in the American Journal of Surgery, Anesthesia Supplement, January, 1919:

In October, 1917, I reported in a paper which was published in the American Journal of Obstetrics, the results of the use of gas as an agent for the production of analgesia in a series of 476 cases. This series of cases covered the work which we had done with gas for this purpose from March, 1915, until the first of February, 1917. Since the termination of this series of cases, reference to the hospital records show that up to May first of this year we have used gas as an analgesia in 187 further cases, the sum of these figures giving us a series of 663 cases in which we have had the opportunity to observe the value of this method of relieving pain. The cases which make up this series comprise the private cases of members of the attending staff of the hospital; the cases of the ward service, and also those which were brought in from time to time by outside physicians.

METHOD OF ADMINISTRATION.

THE ADMINISTRATION of gas in all cases was done by our permanent staff in the obstetrical division, hence a uniform technic was maintained, rendering all cases available for statistical study. Our technic is quite simple. The administration of gas is begun in primiparæ at or a little before the termination of the first stage. In multiparæ it is usually begun a little before the completion of the first stage. We try in so far as possible, not to administer gas for a longer period than three hours, as there appear to be theoretical objections for its longer use. In our earlier work we had a considerable number of cases which ran over a longer time than this without any untoward experience. However, the period of three hours covers in a great majority of cases the time of greatest suffering.

In cases in which a long and tedious first stage is anticipated, much relief may be obtained from the use of morphin hypodermically. The actual administration is carried out by one of the permanent staff of anesthetists who has become familiar with the administration of analgesia, or by an interne who has had some experience with it.

The gas is begun immediately at the onset of a pain, if possible before the contraction becomes apparent to the patient as pain. The patient is asked to breathe deeply and quickly the number of breaths which are needed, varying in different cases. During the second stage if the obstetrician will keep a hand upon the sterile sheet covering the abdomen, he may often feel the beginning of the contraction before pain is apparent to the patient, and request the anesthetist to commence the administration of gas instantly. Failure to observe this rule of exceedingly early administration militates very seriously against success in gas analgesia.

TECHNICAL POINTS.

I BELIEVE THAT slowness in beginning the administration of gas after the onset of pain is responsible for more failures to relieve suffering than any other one factor. Each patient is to some extent a law unto herself as to the exact amount of gas which may be needed. Some will obtain a very satisfactory degree of relief from pain with three or four breaths while others find it necessary to take more. We have found in some cases that it was necessary to give gas throughout the entire extent of the pain.

The percentage of gas varies somewhat in different patients. In some cases gas alone has been used, but the administration of nitrous oxid unaccompanied by oxygen should be permitted only where a small number of breaths are necessary to produce analgesia. Oxygen may be added in percentages varying from 5 to 15, according to the individual necessities of different patients, but the average case does very satisfactorily with 5 to 7 per cent. The exact number of breaths to the percentage of oxygen must be determined by the operator shortly after the beginning of the administration of gas, and, having determined what is necessary for the relief of pain in the individual patient, one should continue to administer it in the same way. *Rebreathing is not permitted at any time while the child remains within the uterus.*

It is very necessary to distinguish between analgesia and anesthesia. Patients should not be permitted to pass beyond the zone of analgesia. Should this be permited, we lose the cooperation of the patient and struggling becomes more likely than if it is not done. Cyanosis must absolutely be avoided and in the hands of a competent anesthetist may be prevented.

As the end of the second stage is approached, we permit a little more gas with each pain and at the time of delivery, for the last three to five pains, I have been for some time in the habit of adding a little ether through the gas machine. I find that this promotes relaxation, makes it more easy to control the head, and delivery may be accomplished without the patient being at all conscious of it.

Episiotomy may be done at this time with the slight addition of ether without any appreciation of pain. Ether given in this way and for so short a time does not produce narcosis of any length and the patient rapidly awakes and only very rarely has any nausea.

RESULTS.

AS TO THE RESULTS which we have been able to attain by the technic just described, I will quote from the report which I have referred to above in the American Journal of Obstetrics in which in 476 cases, it was found that unsatisfactory results were attained in 7½ per cent. References to the history sheets in the 187 cases which we have had since the publishing of that report show that successful relief of pain is being attained in fully as high a percentage of cases at present.

We have so far not had a case of fetal death in which the death seemed fairly chargeable to gas. There has in every instance of still-birth been some other competent cause for the loss of the child. Of the 476 cases which I have already referred to, 32 babies were born asphyxiated to a greater or lesser degree. The histories of these cases show that in 12 of them some reason other than anesthesia existed which might be looked upon as responsible for the asphyxia. In 7 of these cases forceps operations had been done. One was a breech extraction, one threatened eclampsia and one child had a spina bifida and lived but three days. One case was a severe toxemia of pregnancy and one a premature labor. We have therefore 20 cases which may be looked upon as having shown more or less asphyxia.

Since beginning the use of gas we have not observed that hemorrhage of the new-born has increased in frequency. There have been a number of cases of hemorrhage of the new-born, but it is quite striking that some of the most serious of these have been cases which had received gas but a very short time. It should be remembered by the anesthetist, however, that asphyxia will cause hemolysis without regard to what may be the cause of the asphyxia, hence cyanosis must be avoided and, since its avoidance is largely dependent upon the development of a proper technic, there is little excuse for its occurring. It seems also to be a fact that anesthesia to the point of unconsciousness with any anesthetic may produce certain changes of cell structure and hemolysis may be looked upon as more likely, but with the proper gas technic, unconsciousness should not occur except at the end of labor and for a very short time.

When the use of gas as an agent for the production of analgesia was first begun there was a tendency by some to emphasize the point that its *administration was exceedingly simple and to give the impression that it might be done by any one. As my experience with it has grown I have gone farther and farther from that point and at present am inclined to disagree with it absolutely. A properly given analgesia does require a certain amount of technic and it has been my experience that the advent of a new interne in the obstetrical division has usually been followed by a period of poorly given analgesias; since then we have tried to train each one of them somewhat in its use.*

I have had no experience with the method of self-administration, that is, the permitting of the patient to start the flow of gas herself by means of a spring valve which she presses upon, and which closes should her finger become relaxed through too deep an influence of gas. I prefer much to have the administration of analgesia under the observation of a competent person.

After an experience of about three years with the opportunity of observing the use of gas analgesia in a number of cases referred to in this report, I feel that this method has given us the best results which we have yet been able to attain in our maternity.

OPERATIVE OBSTETRICS.

THE ADMINISTRATION OF GAS does not diminish either the frequency of the uterine contractions nor the force of the individual contractions. In fact, as the pain of the second stage is so largely done away with, we find that our patients are much more willing to make use of their accessory muscles of expulsion and that the labor is hastened instead of retarded. The intelligent patient with a properly given analgesia will cooperate perfectly, bearing down when requested and stopping immediately if asked.

It has been a matter of frequent observation that a patient who has been complaining bitterly of suffering toward the end of the first stage, perhaps even becoming a little unmanageable, will almost immediately become quiet and amenable to suggestion upon the beginning of gas administration. I feel also that we have been able to carry a number of cases through a tedious second stage where by reason of the fact that the patient was a nervous individual and one who bore pain poorly, the labor might have had to be terminated by high forceps. I can recall several of these which have gone on to the point at which a simple low forceps operation sufficed. This of course has its effect upon the lowering of fetal mortality as well as sparing the mother the trauma of the high operation.

One other factor has impressed me greatly. That is, the relief from nervous exhaustion subsequent to labor by reason of the fact that the mother has passed through that portion of her labor which is accompanied by the greatest pain while under the influence of gas. I believe that the suffering which the patient undergoes is a greater cause for nervous exhaustion than the actual physical labor which she is called upon to perform. The second we cannot take away in a normal labor, but the first we can relieve, and its relief, I am sure, leaves the patient in a far better condition to enter upon her convalescence.

In the field of operative obstetrics, gas anesthesia finds a rather wide application. In that most common of all obstetrical operations, the primary repair of a perineal tear or of an episiotomy wound, gas is a most satisfactory agent when properly given, and in this provision, *"when properly given,"* we find the crux of the whole situation.

Surgical gas anesthesia is exceedingly safe and in a large percentage of operative cases, surgical and gynecological as well as obstetrical, a very satisfactory anesthesia when given by one who has been properly trained in its use. It is neither safe nor satisfactory when administered by one who has not been properly trained. This opinion has been expressed before by those who have had occasion to acquire some experience with it in operative work and after a considerable experience with gas anesthesia in abdominal, pelvic and vaginal work, I wish not only to agree with that opinion but to emphasize it.

I do not permit upon my service that any general anesthetic for operative work shall be given with gas for either a gynecological or obstetric patient except by the hospital anesthetist. Where it is necessary that the services of an interne be used, ether is always chosen.

ADDITION OF ETHER.

A PRIMARY PERINEAL REPAIR is a surgical operation and requires that the patient should be relaxed and quiet upon the table. The patient who is but partly asleep and struggling interferes with asepsis and renders impossible a proper carrying out of even a simple surgical procedure. But as the child is now no longer in the uterus, rebreathing is no longer objectionable and the patient may be anesthetized, exactly as though she were to have any other operative procedure, and should it be necessary, a little ether may be added.

In the giving of surgical anesthesia in this as in all other operations, our aim should be not stubbornly to limit ourselves to one agent for the production of anesthesia, but to produce in the patient safely that degree of narcosis which is necessary for the proper carrying out of the procedure in hand. My repair operations, unless the injury be a quite extensive one, are usually done immediately after delivery and before the expulsion of the placenta. A gas-oxygen anesthetic for this purpose has not, in my experience delayed the expulsion of the placenta except in those cases in which considerable ether is used, and these cases are but very few.

My attitude, however, toward the use of nitrous oxid anesthesia in forceps operations is somewhat different. As I have mentioned above, I object to the use of rebreathing in an obstetric case prior to delivery on account of the fear of overcarbonization of the fetal blood. Without rebreathing it is difficult to secure that degree of relaxation which is necessary for the proper carrying out of even a low forceps operation. I have tried this faithfully many times and have had the anesthetic given by careful and competent anesthetists but with the exception of a few cases had poor results.

I have also tried repeatedly the use of gas oxygen without rebreathing with the addition of ether, but have almost invariably found that the amount of ether required was so great that there was but little advantage over a straight ether anesthetic. After faithfully trying out gas anesthetics for forceps operations over a considerable period of time I have now gone back to straight ether in these cases. I believe that the objections to ether in forceps operations are to be considered much less than the danger of disturbance of asepsis by the sometimes violent movements of the mother under an incomplete narcosis.

For the simple operation of induction of labor by the introduction of the hydrostatic bag, gas oxygen provides us with an ideal anesthetic. Complete relaxation is ordinarily not needed, hence extensive rebreathing is not necessary. However, should rebreathing to a moderate degree be required, inasmuch as delivery is still far off, it may be used, as any carbonization of fetal blood is done away with during the succeeding hours of labor, and, should one fear it greatly, the mother may be given a little oxygen at the termination of the anesthetic. These anesthetics are ordinarily short and gas permits the bag to be introduced without pain and allows the mother to wake up without nausea usually and without the deadening effect upon the uterine contractions which ether produces, when one is desirous that they should be immediately begun.

In case the introduction of more than one bag in the same case is requisite, anesthesia may be repeated, and after dilatation is complete these cases receive analgesia during the second stage, exactly as I have described.

For evacuation of the uterus in cases of incomplete abortion or for the introduction of packing in cases of inevitable or therapeutic abortion, gas is equally desirable. In the hands of a competent anesthetist sufficient relaxation may almost invariably be obtained without the addition of ether and in these cases rebreathing may be used if needed. Cases of this character I have done with gas anesthesia for some years prior to the time we began to use it in obstetric work and in the past five years have used ether in cases of this sort probably not more than a half dozen times.

In Cesarean section I have had no experience with the use of gas, as I have always done these cases under ether. I have feared the effect of rebreathing upon the fetus and have not felt that sufficient relaxation could be gotten without rebreathing to make the procedure wholly safe. I feel also that the preliminary dose of morphin and scopolamin an hour prior to operation, which renders the giving of surgical anesthesia by gas oxygen much more easy, is objectionable upon obstetric grounds, inasmuch as delivery will occur in too short a time subsequent to the giving of these drugs. That morphin or scopolamin should not be given when delivery seems likely to occur in less than three hours is an obstetric rule, the validity of which is conceded even by the protagonists of the so-called *twilight sleep*. I intend, however, as soon as the opportunity presents in a nephritic case, doing this operation under local anesthesia with the possible addition of some gas, but with no preliminary administrations of narcotics.

CONCLUSIONS.

1. Gas furnishes an ideal method of relief of pain in normal labor, the safety of which, in competent hands, has been demonstrated by a large number of cases.

2. For all of the minor operative procedures in obstetrics and gynecology, such as primary perineal repairs, evacuation of the uterus, introduction of bag or gauze, gas supplies an efficient mode of narcosis which is free from most of the objections of ether.

3. For all operative procedures which are done before the delivery of the child, rebreathing should not be used.

4. In complete anesthesia in obstetric work as in complete anesthesia in surgery, and gynecology, gas should always be administered by some one properly trained in its use and the fact that gas is highly safe in competent hands must not distract our attention from its dangers in untrained hands.

5. It is best to limit analgesia to a period of three hours.

SACRAL ANESTHESIA . GENERAL CONSIDERATIONS . ANATOMICAL CONSIDERATIONS . EXTENT OF ANESTHESIA . TECHNIC . ANATOMICAL LANDMARKS . PRECAUTIONS . EXPERIENCES . SPECIAL UTILITY . BLOCKING THE SYMPATHETIC TO PREVENT SHOCK IN THE COMBINED OPERATION FOR CANCER OF THE RECTUM OR RECTO-SIGMOIDAL JUNCTURE . SOME IMPROVEMENTS AND MODIFICATIONS OF TECHNIC . CAUDAL (SACRAL) ANESTHESIA IN GENITO-URINARY SURGERY . HISTORY . FURTHER ANATOMICAL CONSIDERATIONS . THE SACRUM, ITS PLEXUS AND HIATUS . DISTRIBUTION OF NERVES FROM THE SACRAL PLEXUS . PREPARATION OF SOLUTION . DOSAGE . TESTS FOR INSENSIBILITY . SUCCESS AND FAILURE . TECHNIC OF ADMINISTRATION . UNTOWARD EFECTS . TOXICITY . ADVANTAGES OF SACRAL ANESTHESIA . ILLUSTRATIVE CASES . RESULTS ACHIEVED .

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IN ADDRESSING the American Association of Anesthetists, during the Sixth Annual Meeting, Jerome M. Lynch of New York City, drew attention to the fact that in 1913, he first published the results of his trial of some 20 cases of sacral anesthesia, being at the time unaware of the fact that Cathelin, Stockel, Loewen and others had been employing this method with marked success. Lynch first adopted this form of anesthesia in a search for one other than hypodural to prevent shock in the combined operation for cancer, where the upper rectum and sigmoid were involved. Satisfied with the results obtained, Lynch and his coworkers at the New York Polyclinic, extended the scope of this procedure to embrace operations on the perineum for hemorrhoids and other conditions, finding that a minimum of discomfort and danger followed.

Considering that sacral anesthesia enjoys safety, increases efficiency, and produces few after-complications, it is surprising, writes Lynch, how seldom it is employed.

GENERAL CONSIDERATIONS.

ONE FREQUENTLY READS of the employment of hypodural anesthesia for hemorrhoids. We took exception to this many years ago, as being fraught with danger that was out of the proportion to the gravity of the operation. We, in our turn, were taken to task by men employing the hypodural method, claiming that their way was quite as safe as any other form; but I notice that the men then loudest in their praise of this procedure are no longer using it. More than one of our colleagues who were very keen on spinal anesthesia, has now abandoned it, realizing its grave dangers.

I do not wish to convey the impression that I am comparing the usefulness of hypodural with extradural anesthesia. That is far from my purpose. Both have their field of usefulness. But, within its special scope, there is no comparison from the standpoint of safety between hypo- and extradural anesthesia. Nor do I wish to be understood to be advocating sacral to the exclusion of local or general anesthesia. There are indications for each, and the surgeon of experience will instinctively select the proper one.

Sacral anesthesia consists of the injection of an anesthetizing solution such as novocain or cocain into the intradural space through the sacral canal. It is purely a conductive anesthesia, by which more or less extensive complex of sensory nerves are interrupted. It will act upon the spinal nerves after they have left the dural and so block all sensory impulses. Cathelin, the great French surgeon, was the first to demonstrate the possibilities of this method. He injected three cc. of a 1 per cent. solution of cocain into the sacral canal of a dog, resulting in a complete anesthesia of the whole body.

Encouraged by this experimental work on animals, he applied the same procedure to man, meeting with disappointing result, the experiment being a total failure. However, he was not discouraged. He continued his efforts, confined himself to various neuropathologies, such as pelvic neurosis, neuralgias and incontinence of urine, and in over a thousand cases obtained good results. Stoeckel, learning of Cathelin's work, immediately perceived its value in obstetrics. He modified Cathelin's technic somewhat and succeeded beyond his expectations in reducing the pain of labor and also found it helpful in relaxing the perineum in eldery primiparas.

Loewen, in 1910, followed Stoeckel; then came Schlimpert, Schneider, Koenig. Each added his quota in exploring and developing this field. They believed that its usefulness could be extended by increasing the amount of the solution and adding adrenalin and bicarbonate of soda and also by using a much longer needle. By these methods and by the addition of narcotics, they were able to perform abdominal operations. This they termed high extradural anesthesia. It would seem as though they had gone a bit beyond the legitimate field and that it would be much better to adopt some other form of anesthesia in laparotomy. We further believe that by developing the legitimate field of sacral anesthesia, great things can be accomplished. Wilms recommends the injection of 20 cc. of saline, before injecting the novocain; and believes that by following this method, the novocain absorption is limited, and better local anesthesia is obtained. Strauss suggested the addition of sodium sulphate, to prevent the decomposition of adrenalin.

ANATOMICAL CONSIDERATIONS.

THERE ARE A FEW anatomical features worth considering. *First*, the conformation of the sacral canal and the posterior surface of the sacrum. *Second*, the gross anatomy of the lower spinal cord and sacral roots.

The Sacrum.—The posterior surface is composed of the fused laminæ and their modifications. The upper borders of the first laminæ slant downward, and below their junction is a well-marked spine. Below this the laminæ of the sacral vertebræ are fused and the spines small. The laminæ of the fifth sacral *never* join, and those of the fourth frequently do not. This *is the important* point, for thus it leaves the lower end of the canal uncovered. This is the sacral hiatus, and the place through which we inject the anesthetic.

The laminæ that do not meet end in tubercles, each representing, of course, one-half of a spinal process. The lower two project downward at the sides of the open canal, and are called the sacral cornua. Right below this, in the median line, is the base of the foramen, and oftentimes a bony knuckle, the sacral coccygeal junction or articulation.

The Sacral Nerves.—The spinal cord terminates as such in a pointed end—the sonus medullaris that usually ends opposite the discs between the first and second lumbar vertebræ. The dura mater of the cord, however, continues and extends to the level of the second sacral vertebra. From the third lumbar vertebra down the lumbar and sacral nerves pierce the dural sheath till they reach their individual foramina and leave. These nerves run a varying distance through the canal—depending upon their destination; they are supported by a loose cellular tissue and are enveloped posteriorly by a thin diffuse anastomosing venous pampiniform plexus.

EXTENT OF ANESTHESIA.

A CONSIDERATION OF THE nerves affected and the regions supplied, shows that the conduction of the ano-coccygeal root nerves, the fifth, fourth, third and second sacral nerves, are affected. These nerves cover an extensive area and form many large plexuses and complexes and nerve centers which are in close harmony with the ever-present great sympathetic. The upper extent of anesthesia and nerve blocking depends purely upon three factors: (1) amount and concentration of the solution, (2) posture, and (3) disposition of the anesthetic. If the patient's pelvis is raised, if a very potent amount of solution be injected, and if the needle be inserted very high, it is possible by the sacral route to anesthetize even the fourth and fifth nerves.

In the low extradural anesthesia—the ordinary type—the nerves affected are the coccygeal nerves and the nerves derived from the coccygeal plexus, namely, the pudic, the inferior hemorrhoidal and the perineal and the dorsalis penis, or clitoris. In addition, the visceral branches of the third and fourth sacral nerves which are distributed as the middle hemorrhoidal, the inferior vesicle and vaginal nerves to the rectum, bladder and vagina, respectively, are also interrupted.

Sometimes the external and internal popliteal are touched by the anesthetic, leading to paresthesias and hypesthesias of the legs and feet, and the small sciatic. These are purely accidental. The pudenal plexus is affected the most. It is formed by contribution from the first, second and third sacral nerves, and from the entire anterior primary division from the coccygeal nerve.

As a rule, isolated nerve trunks are also affected, and it was this phenomenon that caused Stoeckel to apply it in obstetrics. He called attention to the flaccid floor of the pelvis after extradural anesthesia and to the relaxation of the sphincter, which is particularly useful in some surgical operations.

With the nerve distribution in mind, it can readily be seen that with perfect anesthesia any pelvic, perineal, rectal or bladder operation could easily be done.

The method we follow has been developed within the last four years by ourselves and by those we have mentioned.

TECHNIC.

WE FIND IT BEST to employ a glass syringe which holds about 20 cc. and which fits comfortably into the needle such as is generally used in hypodural anesthesia. One of our assistants had a serious accident when introducing the needle, about three centimeters of the end of the needle remaining in the canal after the needle was withdrawn. Since then we have employed a platinum needle. When we speak of a needle, we mean a very fine trocar and cannula, like that used in spinal anesthesia. After the trocar is removed, the cannula can be passed through the canal without injuring the veins, which lie in the loose tissue within the canal. Furthermore, there is less danger of penetrating the dura, as happened to us on two occasions by using the needle we have just described. Some of our European colleagues introduce the needle when the patient is in a sitting posture. We prefer the left Sims' position.

ANATOMICAL LANDMARKS.

WE HAVE EXAMINED a number of cadavers, and taken measurements at different points, to establish, if possible, a fairly accurate method by which the opening of the canal can be located. At first measurements were taken from the posterior superior spine of the ilium to the tuberosity of the ischium on both sides, but the bi-section of these lines did not come anywhere near the opening. The next measurements were taken from the posterior superior spine of the ilium to the left margin of the sacrococcygeal joint, and the same on the other side, and we found the opening of the canal in the majority of the cases, to be where these two lines bisect. Here inject one or two cc. more, and this is made much simpler, if the needle has been left in place.

PRECAUTIONS.

IT IS IMPORTANT for the fluid to be absolutely sterile and freshly prepared; also of the same specific gravity as the blood, in order that it may be readily absorbed.

After anesthesia is established the needle is withdrawn, and some cotton and collodion placed over the wound. The patient is then placed in whatever position is desirable in order to perform the operation, and the rest of the procedure depends upon what particular operation has been undertaken. If a prolonged anesthesia is necessary, urea and quinin may be substituted for cocain. I have not as yet determined how much urea and quinin are necessary in order to produce complete anesthesia, or what would be the duration of the anesthesia under this procedure. I shall work this out later on.

EXPERIENCES.

WE HAVE USED this method of anesthesia in eighty different cases, and in all but sixteen cases the anesthesia was perfect and all that could be desired. One case in particular was very interesting. The patient was a young man, twenty-three years of age, with a carcinoma involving the prostate and rectum. We were able to dissect the rectum and remove the prostate with absolutely no pain. However, when the dissection was almost completed and we were ready to separate the rectum from the peritoneum we encountered some pain and pronounced shock when pulling on the rectum. He also had severe pain when an attempt was made to cut the peritoneum with the scissors. Before proceeding further we had to give the patient a general anesthetic in order to complete the operation.

From this case we learned the lesson that operations involving the peritoneal reflexion are impossible with sacral anesthesia. If I had used my usual procedure of blocking the hypogastric ganglia above I could have completed the operation without further pain. The shock which occurred when I pulled on the peritoneal reflexion was due to pulling on the lumbar and inferior mesentric plexus of the sympathetic, and to the fact that we had not blocked this point.

The other cases were operations involving the rectum only, and all were accomplished with the greatest ease to the operator and comfort to the patient. In no instance did we use more than 10 grains of novocain, and that amount was used in the operation which involved the removal of the rectum and the prostate. The point of interest in connection with this case is worth mentioning. Before dissecting the rectum free from the urethra and removing the prostate, one of my assistants tried to pass a sound into the bladder. Some difficulty was experienced on account of a posterior stricture. After gentle manipulation we succeeded in passing the sound into the bladder, and during all of this procedure the patient had not the slightest sensation of pain or discomfort.

SPECIAL UTILITY.

THE VALUE OF THIS method, therefore, in cases of stricture of the urethra in hypersensitive individuals in whom it is necessary to explore the urethra or the bladder can easily be understood. Especially will it be found serviceable in old men on whom it is necessary to do a prostatectomy, or in any procedure involving the urethra or bladder. In protracted and intractable pruritis great relief can be obtained by this method of anesthesia. It finds its greatest field of usefulness in cancer involving the rectum and sigmoid, because here we can completely block the sympathetic by a combination of hypogastric and sacral anesthesia.

Through the kind permission of Professor Stockard, and his associate, Dr. Burrows, the writer had an opportunity of studying some excellent dissections of the sympathetic, together with dissections of the spinal cord, and from these studies, we have evolved a very simple plan of blocking the sympathetic, which will be, so far as we can judge from a limited experience, of inestimable value in preventing shock in the combined operation for cancer of the rectum or rectosigmoidal juncture. Furthermore, we have so improved the technic as to make the operation much easier and safer and, while the procedure requires surgical dexterity and judgment, yet it is so simplified that very much less time is necessary for its accomplishment, and the danger from hemorrhage has been almost entirely eliminated.

The patient, after having been prepared for operation in the usual manner, is given ¼ gr.

morphin and $^{1}/_{200}$ gr. hyoscin, unless for some reason this is contraindicated, and is then placed in the left Sims' position, and sacral anesthesia is induced by the method already detailed.

After this has been accomplished, the patient is placed in the lithotomy position, and the abdomen painted with tincture of iodin, this afterward being washed off with alcohol. The object of this is to prevent any irritation of the peritoneum from the iodin, some cases of chemical peritonitis having been reported from this cause.

The abdomen is then opened by a median incision, and a self-retaining retractor placed in position. The patient is put in the Trendelenburg position, and the small intestines carefully walled off with one large pad about the size of an ordinary towel. We prefer this to a number of smaller pads, and it has worked very well so far. When the small intestines have been thoroughly packed off, the patient can be returned to the prone position, if it is demed advisable.

BLOCKING THE SYMPATHETIC NERVES.

THE NEXT STEP is to block off all the sympathetic nerves within the triangular space bounded by the common iliac. The needle used for this purpose is about 2 inches long, curved on the flat, and has a probe point, the object of this point being to prevent perforation of the iliac veins. The technic is as follows: An incision is made in the mesentery on one side at the apex of the common iliac arteries, slightly above the bifurcation of the aorta. The needle is passed in through this incision, and all the space between these arteries is infiltrated with a solution of 1 per cent. novocain. If necessary, the inferior mesenteric plexus can also be treated in the same manner. After this has been accomplished, the sympathetic nervous system of the entire hypogastric plexus is blocked. Now, by means of a scissors curved on the flat, the right mesosigmoid is slit as far down as the bladder, or uterus, as the case may be, and continued around on the anterior surface of the rectum to the other side, thus separating the rectum from the bladder or uterus. The right leaf of the mesosigmoid is treated in the same manner. When this has been done, the sigmoidal artery is double tied close to its root. Afterward, the superior hemorrhoidal artery is double tied, and the surgeon, with a scissors curved on the flat, proceeds to scoop out all the fat and glands between the folds of the proximal mesosigmoid. This scooping process continues from the promontory of the sacrum to the levator ani muscle. After the middle hemorrhoidal artery, which is a branch of the obturator, has been clamped, both leaves of the mesentery are cut, and this cutting process is carried down to the levator ani muscle. The rectum can now be readily separated from the prostate and urethra as far down as the levator ani muscle. The tumor and sigmoid are then packed down in the pelvis, and the peritoneum dissected up from the side of the pelvis and attached to the bowel, thus making a new diaphragm about 2 inches higher than the former peritoneal attachment. All raw surfaces are covered by attaching the peritoneum to the gut, either by a continuous catgut suture, or by several interrupted sutures, and the abdomen closed in the usual manner. This entire procedure should not occupy more than thirty minutes.

After the abdomen has been closed, the patient is placed in the lithotomy position, and an incision made, beginning about ¼ inch back of the posterior commissure, to the sacrococcygeal joint. The levator ani muscle is then performated by means of a scissors. One of two procedures may then be followed: The gut can be pulled through the levator ani muscle posterior to the anus and the tumor removed, after which both ends of the gut are treated with carbolic acid, and the proximal end, with the distal, invaginated through the anus, and an end-to-end anastomosis made. Or, and we prefer this method, the mucous membrane may be dissected from the anus, just as is done in the Whitehead operation, and the dissection continued until the bowel is thoroughly freed. The bowel and tumor are then pulled through the anus, the tumor removed, and the gut sutured to the skin. A drainage tube is then placed in the hollow of the sacrum and packed around with iodoform gauze. The posterior incision is then closed by means of interrupted silkworm-gut sutures, thus completing the operation.

This operation can be done at one sitting, or in two stages, depending upon the condition of the patient and the rapidity with which the operator can work.

In conclusion we would ask that sacral anesthesia and blocking of the sympathetic be given a more extended trial in suitable cases so that the limits of its usefulness can be determined.

ENCOURAGED BY THE work of Cathelin, Loewen, Gros and Harris, Bransford Lewis and Leo Bartels of St. Louis, Mo., made a study of sacral anesthesia and then adapted it for use in genito-urinary surgery, for which it is particularly and especially satisfactory. They reported on some 85 cases of sacral anesthesia to the Southern Surgical and Gynecological Association in 1915, and have since extended their use in the method. They give the following account of their initial studies, observations and experiences.

HISTORY.

IN 1901 AND 1903 Cathelin[1] proposed the use of normal saline injections into the sacral canal for the purpose of allaying certain nervous manifestations connected with the urinary tract: enuresis in boys and girls and tabetic crises. Encouraged by some success in this endeavor, the same author later tried to induce anesthesia by injecting in a similar manner, but this proved unsuccessful with him and with other French experimenters of that period.

It was not until 1910 that material success was reported in this regard. Then Loewen[2] described his use of one to two per cent. solutions of novocain in normal saline solution, used in this way and the anesthetic effect he secured therefrom.

Gros[3] advised an alkaline base for the solution as promoting the intensity of anesthetic effect, and made use of novocain bicarbonate, together with a small addition of adrenalin.

Loewen made use of the sitting posture for the patient until the anesthesia was well under way, and began with 20 or 25 ccm. While he mentioned that the anesthetic effect was somewhat variable, he claimed that very satisfactory results were obtained in many instances. Analgesia had been noted in the gluteal region, rectum and anus, skin of the scrotum and penis, and of the upper and inner parts of the thigh; and in women, the vulva and vagina. Loewen thought that probably the prostate, also, would be found to be analgetic through the same agency, though up to the time of his report he had had no opportunity of confirming this belief.

In reviewing the subject of nerve-blocking for local anesthesia, Harris[4] mentioned the sacral method and reported having used it with good effects. This was our first introduction to the method. While we then had little to go on, the method seemed logical, and we had had experience with Cathelin saline injections in certain cases with varying success but no bad effects.

We then essayed caudal anesthesia in some eighty-five cases, with results so favorable that we felt justified in making the initial report herewith presented.

ANATOMY.

THIRTY-ONE PAIRS of nerves branch off from the spinal cord, emerge through the foramina, and are distributed to the several parts of the body which they innervate. They are divided into five groups: the cervical, dorsal, lumbar, sacral and coccygeal.

Sacrum.—Although originally composed of separate segments, the sacrum in adult life is

1. Cathelin: Les injections epidurales, Paris, 1903, p. 89.
2. Loewen: Zentrbl. f. Chir., 1910, No. 20.
3. Gros: Arch. f. exper. Path. u. Pharm., p. 708.
4. Harris: Surg., Gynec. & Obst., 1915, Vol. xx, 193.

blended into one bone. For present consideration its most interesting features are its *central canal* and its *foramina* (Fig. 1). The canal is a continuation downward of the spinal canal, but at the second sacral segment communication between these two parts is cut off by the closure of the dura mater around the nerve branches (Figs. 2 and 3). This is not only demonstrable anatomically, but Loewen[5] found that colored fluids injected into the sacral canal never appeared in the spinal canal or colored the upper part of the cord, showing the complete isolation of these two parts of the canal from one another by closure of the dura mater. So that although the nerves are transmitted from the spinal canal down into the sacral canal, there is no other communication between the two. This fact marks the distinction between this method of securing anesthesia and that termed spinal anesthesia, in which the fluid is injected directly into the spinal canal. It likewise indicates that the two methods should not be confused with one another.

Fig. 1. Sacra, and varying forms of sacral hiatus (P. Bull.).

The nerve branches that descend thus from the spinal into the sacral canal are called the sacral nerves. From the sacral canal they pass through the sacral foramina out into the pelvis, forming then the *sacral plexus* (Fig. 4), one of the most important of whose branches is the pudic, distributed to the genito-urinary organs.

The sacral canal is enclosed in bony walls except at its lower end; here through non-development of the spinous processes the posterior bony wall is lacking and is replaced by a ligamentous membrane or covering. This opening is called the *sacral hiatus*.

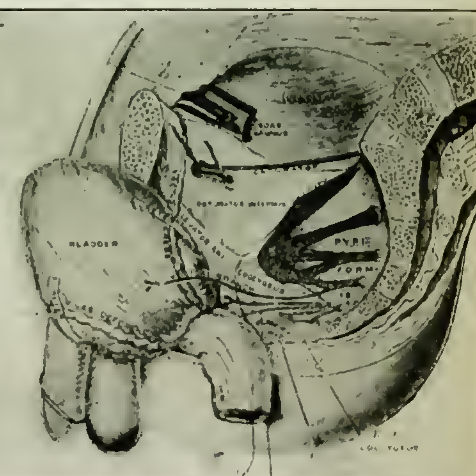

Fig. 2 (at left). Sagittal section of spine, showing spinal and sacral canals (Cunningham).

Fig. 3. Showing separation of spinal and sacral canals by closure of dura mater. Sacral nerves exposed (Gray-Spitzka).

Fig. 4. Sacral plexus of nerves and distribution (Gray-Spitzka).

It is through this hiatus that the hypodermic needle is directed for delivery of the fluid for anesthesia. The opening is variable in size in different individuals (Fig. 1), but is practically always large enough to permit the introduction of a needle.

5. Loewen and Gaza, D. von: Zeitschr. f. Chir., 1911, p. 300.

The sacral canal is flattened from before backward, and its caliber grows smaller as it curves downward toward the coccyx (Fig. 2). In the male the curve of the sacrum is fairly evenly distributed over the whole length of the bone, but in the female the upper part or base of the sacrum is projected more sharply backward for the increase of pelvic capacity pertaining to that sex. These variations have an influence on the ease or difficulty of introducing the long hollow needle through which the injection is made. The axis of the canal must be threaded by compensating movements while advancing the needle.

Distribution of Nerves from the Sacral Plexus.—The chief divisions of the sacral plexus are the sciatic and pudic nerves. The pudic terminates in three branches, namely, (1) the dorsal nerve of the penis, (2) the perineal nerve, and (3) the hemorrhoidal. These supply the skin and the structures of the penis, scrotum, perineum, prostate and bladder; and the inner surface of the thighs posteriorly. A structure *exclusively* supplied by a certain nerve may be anesthetized by deadening that nerve; but when the structure is supplied by another nerve, also, the deadening of one nerve only does not suffice for anesthesia; the collateral nerve holds the tissues in a sensitive condition. This accounts for the fact that the lower extremities are not made analgesic by anesthetizing the sciatic nerve. Collateral innervation maintains sensibility.

PREPARATION OF SOLUTION.

VARIOUS DRUGS have been added to the novocain solution to make its effect more efficient and enduring, but our experience has led us to believe that the two most useful adjuvants in this respect are potassium sulphate and adrenalin. The addition of these drugs permits the use of novocain in much weaker solution while still retaining its effectiveness.

Chloretone, although a local anesthetic and antiseptic, has been discontinued by us because of its irritating effects and also because analgesia has seemed just as good without it. The following solutions are freshly prepared before using:

A. One per cent. solution of novocain.

B. One per cent. solution of postassium sulphate.

When ready for use these two solutions are combined in a sterile glass, and two drops of adrenalin solution (1:1000) are added for each 30 ccm. of the combined solution. Freshly distilled sterile water should be used for making the solutions.

Dosage.—From forty to ninety cubic centimeters of the combined solution are injected, according to each individual case; the more sensitive individuals and the major operative procedures requiring the larger amount.

Prostatectomies demand larger quantities and more complete anesthesia. If one injection does not produce sufficient anesthesia, an additional amount may be used.

Tests for Insensibility.—It is not advisable to apply tests before fifteen minutes following the giving of the injection. They are liable to lessen the confidence of a nervous patient in the success of the method. At twenty minutes the effect should be manifest or at its best. In prostatectomies or vesical operations, a part of this time is occupied in making the prevesical incision under ordinary infiltration anesthesia (Fig. 5). When the operator arrives at the bladder wall he finds it insensitive and ready for incision. Previous to this, if desired, a test may be made by sounding the prostatic urethra and bladder, both of which should be influenced by the caudal anesthesia.

SUCCESS AND FAILURE.

JUST AS WITH THE use of drugs for any purpose and by any method, so there is a certain variability in the effectiveness of this method for producing anesthesia. Aside from individual susceptibility, there may be other reasons explanatory of this. The capacity of the sacral canal may be large or small, requiring a greater or lesser amount of fluid to fill it and exercise the pressure-effect on the nerves that is so essential.

We have found it serviceable to use a larger quantity of the more dilute solution than was formerly employed. Eighty or ninety ccm. of the one-half per cent. solutions seem preferable to half that quantity of one per cent. solutions.

Loewen reported 15 per cent. failure in forty-seven cases, using 20 to 30 ccm. of 1 to 2 per cent. solutions. Our earlier experience gave about the same percentage of success (85), which seems likely to be improved under further study and use of the method. Its newness to us, together with the paucity of literature regarding it, led us to feel our way in increasing the quantity of fluid injected rather than striving too ardently for uniform success.

Fig. 5. Infiltration of suprapubic tissues.

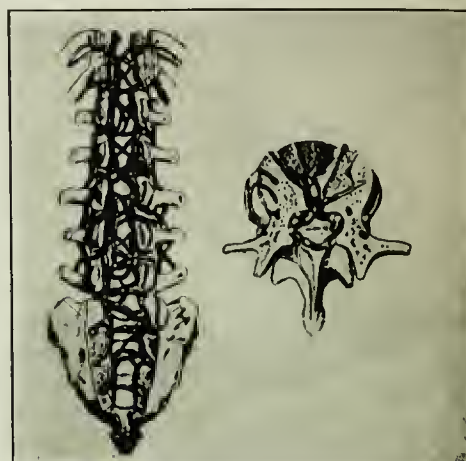

Fig. 6. Venous plexus of spinal column (P. Bull.).

But latterly we have used eighty or ninety ccm. of anesthetic fluid in a number of cases, without observing that it induced any more disturbance than the lesser quantities had given. The hypodermic administration of morphin or pantopon, given shortly beforehand, contributes to the effectiveness of the result.

Harris says that so far the nerve-blocking methods have been accompanied by no mortality. With two possible sources of danger eliminated, the sacral method of nerve-blocking would seem capable of maintaining that enviable reputation. These possible dangers are, injection of the fluid into a vein (Fig. 6) and injection into the spinal canal. They are obviated by definite maneuvers related in the description of technic.

It is difficult to anticipate any other cause for anxiety in this respect.

The difficult cases for caudal anesthesia are the obese, the very nervous, the hysterical, and children. Loewen has advised against its use in the aged, but we have found that these are the very cases in which it is especially advantageous. It has made operation possible in a number of cases debilitated and decrepit from advanced age and the ravages of urinary obstruction and sepsis, its freedom from shock and other depressing influences making it particularly desirable for this class of cases.

TECHNIC OF ADMINISTRATION.

THE PATIENT IS PLACED on his right side, with his head slightly elevated, and is instructed to bow his back strongly, bringing his knees and chin as near together as possible.

The area over the sacrum and the immediate neighborhood is cleaned with benzin, dried, and painted with iodin.

The sacral hiatus is sought for and is found just below the spinous process and above the coccyx (Figs. 7 and 8). The rudimentary sacral spinous processes lead down to it.

Having infiltrated the skin and deeper soft tissues over the hiatus with the same anesthetic fluid as is to be used for the sacral canal, a little massage serving to diffuse the solution to better

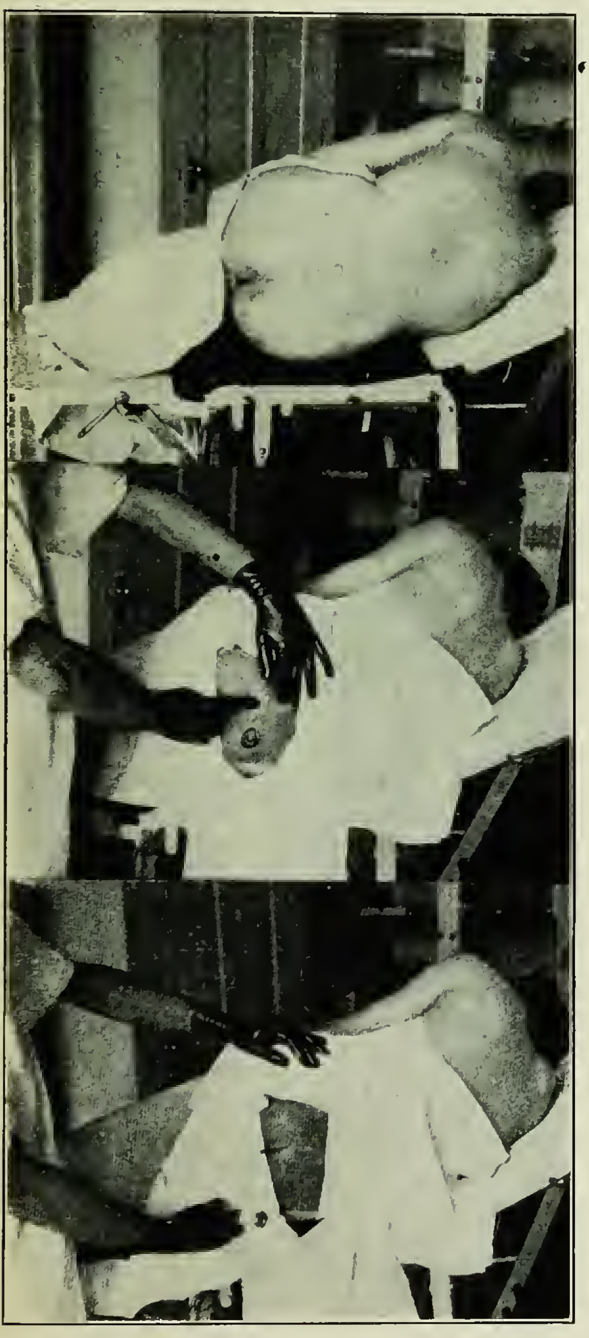

Fig. 7. Landmarks for caudal anesthesia.
Fig. 8. Locating the sacral hiatus.
Fig. 9. Needle inserted into sacral hiatus.

advantage, the long needle fitted with a trocar wire is inserted into the sacral hiatus (Fig. 9), passing through the membrane that covers the hiatus. The needle in being introduced is at first held at an angle of 45 degrees with the skin surface, but as soon as the operator feels the penetration of the membrane by the needle, the syringe is depressed almost to a level with the body-plane at that point.

The needle is made to follow the axis of the canal, which it penetrates for a distance of 1.5 or 2 inches. When placed the trocar wire is withdrawn, and opportunity is given for avoiding the two dangers previously alluded to. If the needle has gone up too far and passed through the guarding dura mater into the spinal canal evidence will be given in the escape of numerous drops of spinal fluid through the needle. In this case the needle must be withdrawn until its point rests in the sacral canal and no more spinal fluid flows. If there is bleeding, indicating that a vein has been punctured, the position of the needle is changed so that an inadvertent intravenous injection be not given. In case there is no bleeding it is well to make assurance doubly sure before injecting the anesthetic fluid. To that end a few drops of normal saline solution are first injected and permitted to return through the needle, thus removing a possible clot or shred in the needle. Blood will assuredly flow at this point if a vein be the resting place of the needle.

If not, and all things seem satisfactory, the injection is proceeded with; 20 ccm. at a time being sent slowly and steadily through the needle by the Record syringe, repeated until the desired quantity is reached.

Some patients indicate the blocking effect on the nerves by complaining of pains or peculiar sensations down the thighs and legs. It has seemed to us that anesthesia portended better when such complaints were made.

Occasionally it is found that a curved needle is more favorable for threading the canal than a straight one, conforming to a more sharply curved canal or a smaller hiatus.

UNTOWARD EFFECTS.

ON ONE OCCASION, before the technic described was adopted, the beginning of the injection was marked by emphatic complaints by the patient of severe pain in the head and chest, weakness, with undue frequency and irregularity of the pulse. It was recognized at once that the injection was *intravenous* and it was promptly discontinued. The symptoms passed off shortly afterward and there was no objectionable after-effect.

At other times we have noted transient indications of weakness, moisture of the skin, and frequent pulse, but whether these were due to the effects of the injection or to nervousness and apprehension on the part of the patient, it has been difficult to say. We have had patients that fainted incidental to a rectal palpation of the prostate, from the strangeness of the situation and nervousness of the patient. So that it is not always easy to differentiate between nervousness and toxicity. However, the effects have never proved serious in any case as yet.

If less than a toxic amount of novocain be used, and it is used under the plans and precautions described, we can see no reason why it should prove dangerous or show a mortality.

TOXICITY.

IN REFERRING TO the toxicity of novocain, Braun[6] says that while he had never noticed any disturbance following the subcutaneous injection of 2 per cent. solutions, Loewen had observed typical poisoning symptoms following the injection of 25 ccm. of 2 per cent. solution into the sacral canal. The symptoms consisted of nausea, sweating, anemia, rapid pulse, frequent respiration, feeling of oppression, and haze in front of the eyes. The authors had noted that these symptoms could be avoided by making the injection slowly. In experimenting on the nerve-trunks of the lower extremities, Loewen had used as much as 2.1 grains of novocain without toxic effect. In one case the patient had received 20 ccm. of 4 per cent. solution; in another 30 ccm. of 2 per cent. solution. He has injected 50 ccm. of 1 per cent. solution and larger quantities of 0.5 solution. In only a few of the cases were toxic symptoms noticed. Finally (ibid., p. 180) Braun remarks that, "since Loewen has shown that the 4 per cent. novocain-suprarenin solution is harmless, even in large quantities, the author has been using this solution." And he further remarks: "The toxic action of this drug is less than that from any hitherto known anesthetic substance."

ADVANTAGES OF SACRAL ANESTHESIA.

THE PRE-EMINENT ADVANTAGES of this method do not appear in ordinary routine surgical cases. These can be anesthetized with ether or gas-oxygen with little risk, if administered by an expert. But when an aged individual, so reduced by pain and toxemia, and by back-pressure in his urinary tract that he is utterly miserable and decrepit; so debilitated that he has no resisting powers to stand further depletion; and seems both ripe and ready for dissolution; and so old that there is no promise of restoration from this source; then we have the patient for whom this mode of anesthesia is appropriate and most advantageous. It is a question then of safety first, of life and death, not simply a choice between several equally safe methods of anesthesia.

Fig. 10. Prostate and vesical stone removed under caudal and infiltration anesthesia.

Anesthetized by this method, we have seen just such cases undergo various operative meas-

6. BRAUN: Local Anesthesia, translated by Shields, 1914, p. 124.

ures connected with the bladder and prostate, who both during and after such operations were serene and comfortable, free from cardiac, pulmonary, or gastric disturbances, and ready at once to take liquids and light nourishment.

ILLUSTRATIVE CASES.

Case 1.—P. K—y, age 63, laborer, poorly nourished, chronic rheumatic and inebriate; poor risk from every standpoint. Arteriosclerosis and myocardial degeneration present. Urinary tract septic, urine loaded with pus and bacteria; urination every five to forty minutes. Repeated septic chills and fever. Cystoscopy showed large intravesical prostatic hypertrophy, together with a stone almost as large as a hen's egg. After five days' preparatory treatment, the patient was operated on by the suprapubic route, under caudal and infiltration anesthesia as described, the specimens shown in Fig. 10 being removed. The patient suffered none at all, either from pain or shock; and expressed himself as more comfortable after operation than before it. Recovery was uneventful and the patient was ready to leave the hospital in three weeks.

Case 2.—Wm. Mcg—n, age 76, very feeble ill-nourished, emaciated and cachectic. First essay at cystoscopy under ordinary methods of local anesthesia was a complete failure, the patient squirming and resisting to a degree that prevented even the introduction of the instrument into the bladder. With this experience in mind, and with memories of previous attempts at instrumentation by other surgeons, the patient very impressively informed us that he would submit to operation or anything we wished to do, *only on condition that it was done under ether anesthesia.* In this stand he was backed up by his family. His enfeebled condition made it highly desirable that he be operated on without the addition of any factors of shock or disturbance. Bronchitis present forbade the use of ether.

A little diplomacy paved the way to the use of caudal anesthesia for a second attempt at cystoscopy, five days after the first one. The effect was all that could be desired. The patient was comfortable throughout; relaxation permitted the introduction and complete manipulation of the cystoscope, and from this very satisfactory examination there was confirmation of a previous suspicion of prostatic carcinoma. This diagnosis explained the hyperesthetic condition prevailing locally, as well as the unpromising condition generally. Nevertheless, it was still considered advisable to operate to relieve the obstruction and sepsis present.

The caudal anesthesia had been so eminently pleasing to the patient that he made no further objection to its use in the subsequent major operation; and it was applied with equally as much satisfaction. After suprapubic opening of the bladder, the larger proportion of the growth, hard, dense and resistant, was removed by digging, tearing and morcellement, leaving at least a good channel for the escape of urine, if not preventing the future return of the growth. The latter had involved adjacent structures to a degree that made radical removal out of the question.

But the caudal anesthesia was both effective and innocuous, the patient was in as good condition after the operation as before, and his progress since then has shown that neither operation nor anesthetic added to his disability or distress and it is expected that the remaining tenure of life may at least be more comfortable.

Other simpler cases might be related in which everything has gone more evenly than in these, but it must be remembered that it is solving the difficult and unpromising cases that makes the method attractive or worthy.

Total number of cases	85
Divided as follows:	
Prostatectomies	13
Cystoscopies	68
Cystotomies	2
External perineal urethrotomy	1
Rectal carcinoma	1

RESULTS.

TEN OF OUR 13 prostatectomies needed no other anesthesia; 2 required a small amount of ether.

One required complete ether anesthesia, there being no effect from caudal injection.

Of our 68 cystoscopies forty-six gave excellent analgesia.

Thirteen gave partial analgesia.

Five gave no analgesia; 3 of these 5 failures we believe due to faulty technic.

One of the cystotomies (for calculus) gave good analgesia and the prostate could have been enucleated.

One required a small amount of ether, as curettement of a carcinomatous mass was done.

The one case of external urethrotomy (perineal) gave complete analgesia.

The one rectal case (carcinoma) was a failure.

SPINAL ANESTHESIA . ITS ROUTINE USE . TYPES OF PATIENTS . DOSAGE AND TECHNIC . RESULTS . FAILURES . FAVORABLE AND UNFAVORABLE FEATURES DURING OPERATIONS . AFTER-EFFECTS . OPERATIONS PERFORMED UNDER SPINAL ANALGESIA IN SANTO TOMAS HOSPITAL . DEATHS . THE FIELD OF SPINAL ANALGESIA . CONCLUSIONS . SPINAL ANESTHESIA IN PRISON SURGERY . TECHNIC AND SOLUTIONS . CARE DURING OPERATIONS . SUMMARY OF OPERATIONS . BLOOD PRESSURE, PULSE RATE . DURATION OF ANESTHESIA AND AFTER-EFFECTS . CONCLUSIONS . OPERATIONS IN THE UPPER ABDOMEN UNDER SPINAL ANESTHESIA . OVERCOMING DIFFICULTIES . RECORD OF OPERATION . SOME ADVANTAGES .

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REPORTING ON THE routine use of spinal analgesia in 6,229 cases, Augusto S. Boyd and Carl C. Yount of Panama City, Panama, are able to give the results obtained by this method of anesthesia in the hands of some 27 different operators who have contributed to the record. This is an unique report and Boyd and Yount do not hesitate to describe their unfavorable as well as their favorable experiences. Writing in the Journal A. M. A., February 24, 1917, they detail their collected data as follows:

In 1909 when work on the Panama Canal was being vigorously pushed, Hospital Santo Tomas, the government hospital of the Republic of Panama, found its admissions increasing rapidly without a corresponding increase in equipment and assistance. For this reason more than others, the surgical staff began the use of spinal anesthesia. Since that time it has been used as a routine procedure, except when contraindicated, for all surgical operations below the umbilicus. It has been used frequently for operations on the upper abdomen and rarely for higher regions of the body. The administration of the anesthetic has not been restricted to any one or to any set of operators, but has been used by new internes. In all, twenty-seven different physicians have contributed to this series of cases. This, of course, is not conducive to the best results, but the opportunity to review results under these conditions is interesting and instructive.

TYPES OF PATIENTS.

THE MAJORITY OF our patients are West Indian negroes and native Panamanians of the poorer classes, of low mentality, and are by no means neurotic in tendency. They submit to operation with a minimum of mental distress. These factors are of great importance in this method. *We have found spinal analgesia much less satisfactory on white American and European patients than on those spoken of above. They seem to require a smaller dose to bring on toxic manifestations, they are much more apprehensive, and unfavorable postoperative effects are more frequent and more severe.* To children under 5 years of age we usually give a general anesthetic, although we have used spinal analgesia on children as young as 1 year. Patients in a state of shock from hemorrhage or other cause, and patients with a very low blood pressure from any cause have not been chosen for spinal anesthesia.

In addition we have chosen not to use spinal analgesia on any patients who were prejudiced against the method, in extremely nervous patients, in patients having marked spinal deformity or diseases involving the spinal cord or peripheral nerves, or in patients having a superficial infection near the site for puncture.

In the beginning, many different drugs were tried, both separately and in combination, and with the addition of strychnin and epinephrin. We have obtained the most consistently good results with the following preparation, so that we now use it exclusively:

	Ampule	
	0.5 cc.	1 cc.
Stovain	0.05 gm.	0.1 gm.
Sodium chlorid	0.05 gm.	0.1 gm.
Distilled water	0.5 cc.	1 cc.

DOSAGE AND TECHNIC.

FORMERLY IN LONG OPERATIONS we gave an average dose of 0.085 gm., with a maximum of 0.1 gm. in very robust persons. In the last two years we have cut down the dose to an average of 0.07 gm., with a maximum of 0.085 gm. *It seems unwise to exceed this, on account of the high percentage of patients who vomit and show other toxic symptoms if a larger dose is given.* The duration of anesthesia will usually bear a direct relation to the dose; hence we vary the dose according to the amount of time required for the operation. For operations requiring one-half hour or less, 5 cg. are given. For longer operations the dose is increased proportionately.

For operations below the symphysis pubis, the spaces between the third and fourth or fourth and fifth lumbar vertebræ are chosen. The solution will in most cases gravitate to the sacral curve, and analgesia will be confined to parts below the umbilicus. When it is especially important that there shall be no diffusion upward, the injection is given between the third and fourth in the sitting position, the patient being allowed to remain in that position for about three minutes. Ordinarily the injection is done with the patient lying on his left side. For anything above the pubis, the spaces between the second and third or first and second are chosen. We have found that our solution injected into the first or second space will usually gravitate to the middle of the dorsal curve with the patient in the recumbent position, and that the average limit of analgesia is a little above the tip of the ensiform cartilage. If the head of the table is slightly lowered, immediately after the injection, the anesthesia will be more profound, and more lasting in the upper abdomen. Practically all the operations on the upper abdomen and chest have been done successfully with this technic. When we have anticipated the necessity for a long operation in the upper abdomen, we have injected the area of the cord directly supplying the operative field, as suggested by Babcock.

RESULTS.

FAILURES.—We are unable to give a statement of the percentage of failures for the entire series because the records are not complete in this respect. Following all cases for a period of three months in the present year we note the following:

In 226 consecutive cases injected by one having had a large experience in the method, there was one complete and one partial failure, about 0.8 per cent. In 479 cases injected by six different physicians there were sixteen complete failures, nine partial failures and four repeated injections, about 6.25 per cent. failures. A complete failure is considered one in which pain sense and motor control are not lost, making it impossible to operate. In partial failure there is some loss of pain sense and motor control, but not sufficient for painless operation. The injection is repeated when there has been a complete failure, if it will not cause too much inconvenience. It is not dangerous to repeat the injection; but if the operative field has been prepared in the meantime, one hesitates to disturb everything and turn the patient on his side for a second injection. In this case we usually give a general anesthetic.

Practically all failures are the result of errors in technic and improperly prepared or deteriorated solutions.

Favorable and Unfavorable Features During Operations.—The most gratifying features at the time of the operation are the complete muscular relaxation and the contracted condition of the intestine. It is possible to perform extensive pelvic operations through a very small incision. The intestine can be separated from the operative field with a minimum of handling. This probably accounts for the fact that we see much less postoperative distention after spinal analgesia than after ether narcosis. The complete relaxation of the sphincter ani is a distinct advantage in operations on the rectum and anus. There is no operative shock in extra-abdominal or pelvic operations.

In operations below the pubis in which the usual dose is 0.05 gm., a little over 1 per cent. of the patients vomit. In abdominal operations below the umbilicus in which the Trendelenburg position is not used, 4 per cent. vomit. In the same class of cases in which the Trendelenburg position is used, a little over 9 per cent. vomit. The vomiting is preceded by nausea, restlessness, sweating, pallor, faintness and air hunger. One or more of these symptoms may be present without vomiting. We have repeatedly verified the fact that these symptoms begin to appear in from twelve to twenty-five minutes after the injection. This corresponds to the time when the drop in blood pressure has reached its lowest point. Ordinarily all these symptoms pass off in a few minutes without treatment. They are more quickly dissipated by strychnin, caffein or respired ether, and in severe cases by the intravenous injection of physiologic sodium chlorid solution containing from 5 to 10 minims of epinephrin solution. These symptoms are probably due to too rapid diffusion of the drug to the medullary centers.

On three occasions it has been necessary to stop the operation temporarily on account of respiratory failure. Artificial respiration was begun and continued in each case until the patient was able to breathe. In one of the cases it was necessary to continue the artificial respiration fifty minutes. (In this case we were trying Jonnesco's method. The patient was operated on for tuberculosis of the cervical glands.) All three patients recovered, and the operation was completed in each case without a general anesthetic.

With our system of dosage for operations in the pelvis the average duration of anesthesia is fifty minutes. The limits of duration are from twenty minutes to one hour and forty minutes. Too short duration of anesthesia has been a distinct disadvantage in some cases, necessitating a supplementary general anesthetic.

We have noticed at times a loss of pain sense without loss of motor control. In this case absence of relaxation might be an objectionable feature.

It has been necessary on a few occasions to render the patient unconscious with a general anesthetic on account of extreme nervousness, even when the injection had been otherwise a success.

After-Effects.—Vomiting is a very uncommon after-effect. It has been noted at times in conjunction with symptoms of meningismus, occurring usually about the third day. If postoperative vomiting occurs, it can usually be traced to some definite cause other than that of the anesthetic.

Mild headache and backache occurred in about 20 per cent. of the cases. They yield readily to the usual headache remedies. The severer type of headache associated with vertigo, severe backache, stiff neck, etc., is much less frequent. In our wards it occurs in about 1 per cent. of cases. It is due to slight hemorrhage into the subarachnoid space from faulty puncture. We believe that the condition is an aseptic inflammation of the meninges, due to the presence of a foreign body (blood) in the cerebrospinal fluid. The most effective treatment is repeated spinal puncture, from 10 to 25 cc. of cerebrospinal fluid being drawn off each time. Symptoms usually last from five to eight days, but may continue in a milder degree from two to three weeks. Vertigo is usually the last symptom to disappear. Headaches from deteriorated solutions are much milder than this type, and usually occur in groups.

Temporary loss of vesical control is fairly frequent, following operations on the rectum and perineum. We have never observed a permanent loss of anal or vesical sphincteric control. In the last 3,000 cases there have been two cases in which vesical control was absent for more than two weeks. Similar cases are not infrequent following general anesthetics.

OPERATIONS PERFORMED UNDER SPINAL ANALGESIA IN SANTO TOMAS HOSPITAL, 1909-1916.*

	No.
Chest:	
Wire for fracture	3
Liver abscess	12
Empyema	3
Wounds	2
Abdomen:	
Gastro-enterostomy	2
Tumors	17
Wounds of stomach	4
Fistulas	7
Exploratory	9
Splenectomy	4
Splenopexy	2
Intestine:	
Suture	6
Resection	12
Short circuit	3
Obstruction	14
Meckel's diverticulum	2
Intussusception	3
Fecal fistula	8
Ulcer	1
Tuberculous peritonitis	9
Peritonitis, other forms	12
Appendectomy	451
Prolapse rectum	8
Stricture rectum	37
Hemorrhoids	264
Fistula in ano	97
Cholecystotomy	3
Kidneys:	
Nephropexy	8
Nephrectomy	3
Ureters plastic	1
Gynecology:	
Hysterectomy	341
Myomectomy	10
Tubes and ovaries	513
Suspension of uterus	126
Perineorrhaphy	48
Curettage of uterus	384
Operations on cervix	28
Rectovaginal fistula	5
Vesicovaginal fistula	4

	No.
Hernia:	
Inguinal	687
Femoral	17
Ventral	30
Umbilical	6
Epigastric	2
Genito-Urinary:	
Inguinal adenitis	330
Circumcision	377
Internal urethrotomy	180
External urethrotomy	135
Hydrocele	201
Prostate (infrequent)	7
Amputation of penis	15
Varicocele	18
Testicle	21
Plastic on urethra	9
Extremities:	
Amputation	98
Fractures:	
Wire	18
Plate	13
Graft	7
Nail	2
Cast	90
Infections	482
Ulcers	362
Varicose veins	9
Wounds	66
Tumors	58
Osteomyelitis	42
Arthroplasty	4
Popliteal aneurysm	2
Aspiration of joints	20
Club feet	5
Cystoscopies, examination of fractures, vaginal examination, repeated injections, emergency wounds, etc.	529
Total	6,229

*In many cases more than one operation was done. Each number represents a separate patient.

In three cases we have noticed symptoms pointing to direct injury of one or more branches of the cauda equina. The patients have complained of pain, followed by paresthesias and anesthesia over a limited area of the buttocks or legs. All have been unilateral. All three were improving at the time when they left the hospital. There was no disability.

It is impossible for us to have an efficient follow-up system in this country, so that some of the late after-effects might escape our observation. But this hospital is the only charity hospital in the Republic of Panama, and it is safe to assume that if a patient developed anything of a serious nature he would almost certainly return to us.

We have observed no case in which there was a permanent paralysis of any kind. We have never seen gangrene of any structure resulting from spinal analgesia.

There have been no cases of meningitis developing after the puncture. No case has been observed in which the puncture seems to have caused a point of lowered resistance, for the development of tuberculous or other forms of meningitis or any other spinal lesion.

In view of the reported frequency, of ocular palsy, namely, 1:400, we are at a loss to understand why we have not observed this condition in a single case. It is possible that in the earlier part of the series some cases may have escaped our attention; but in the past four years when the cases have been more carefully observed, we have not encountered a single case. As it is said to occur from seven to thirteen days after injection, some cases may have developed after the patients had been discharged from the hospital.

One patient developed a marked degree of mental derangement which lasted fifteen days, after which she recovered completely. She had undergone a panhysterectomy.

Deaths.—There have been four deaths in which spinal analgesia has been a factor. In only one did it seem to be the sole cause of death:

A young woman was given 0.075 gm. of stovain in the second lumbar space for an operation for retroversion. In the midst of the operation she gradually went into marked collapse, and the radial pulse could not be felt. There was no respiratory paralysis. Ten minims of epinephrin solution in 0.5 liter of normal saline were given slowly intravenously. The symptoms of collapse quickly disappeared, and the radial pulse became strong and full. The operation was completed, and the patient was sent to the ward in fair condition. Twenty minutes later she was found in collapse again. The same treatment was given with prompt improvement. After the immediate effects of the epinephrin had worn off the pulse became very slow and very weak. Stimulants were given, with slight improvement. In the afternoon, four and one-half hours after the operation, the patient again went into collapse. Epinephrin was given but with very slight beneficial effect. The pulse became weaker and slower until death, about twenty minutes after the last injection of epinephrin.

We feel that this death was due to too rapid diffusion of the stovain to the higher centers, on account of placing the patient too quickly in the Trendelenburg position. We have observed two other cases in a similar condition of collapse. Both patients, however, recovered.

A second death occurred in a strong, healthy man who was about to be circumcised. After the spinal needle had entered the subarachnoid space there was a scant flow of fluid. The patient was (unfortunately) instructed to cough, and fluid spurted from the needle. The patient went into collapse immediately and was also unable to breathe. Artificial respiration was started and stimulants were given, but with no effect. The patient died almost immediately. Stovain had not yet been injected. It was suggested that hernia of the medulla into the foramen magnum from relief of pressure during coughing might have caused medullary paralysis This could not be confirmed at necropsy.

This, of course, is a death from spinal puncture; but as spinal puncture is a part of the procedure in spinal analgesia, its mortality should be considered with that of the latter.

The third death occurred in a woman who was undergoing an operation for the removal of a large ovarian cyst. The patient remained in good condition until the cyst was accidentally ruptured during the dissection. The cyst emptied itself almost immediately and, at the same time, the woman went into a state of shock and died in a few minutes, on the operating table. We believe that the only part which the anesthetic could have played in the cause of this death was to lower the blood pressure slightly and thus render the patient more vulnerable to shock.

A fourth case, a pregnant woman, was given stovain, preparatory to a Cesarean section for eclampsia. Having a very high blood pressure, she was considered a favorable subject for spinal analgesia. Shortly after the injection and before the operation had been begun, she went into a violent eclamptic convulsion. It is possible that the convulsion caused rapid diffusion of the stovain to the higher centers with resulting respiratory failure and collapse. Two of the physicians present were of the opinion that the convulsion itself was a fatal one and that the stovain was not the cause of death. The woman became very cyanotic and apparently died from asphyxia.

In a general way we are able to confirm Babcock's conclusions with reference to a comparative consideration of spinal analgesia and ether narcosis. Each has its advantageous and disadvantageous features. While the immediate operative mortality of spinal analgesia is perhaps higher than that of ether, the additional mortality from postoperative complications following ether narcosis would probably about equalize them. There is no condition following spinal analgesia comparable to ether pneumonia in its mortality.

Certain points brought out in this paper indicate that the best results cannot be obtained unless one especially qualified administers the anesthetic. While the unfavorable features have not been excessive in this series, we feel sure that they could have been reduced considerably in the hands of one or several experienced men. Ether is undoubtedly better adapted to routine use.

THE FIELD OF SPINAL ANALGESIA.

SPINAL ANALGESIA HAS a fairly wide field in which it is the anesthetic of choice, in many respects, namely, for hernia, except those varieties occurring above the umbilicus; all genito-urinary operations except those involving the kidney and upper ureters, and for operations on the rectum, anus, perineum, vagina, cervix and lower extremities.

Pelvic operations and other intra-abdominal operations below the umbilicus can be done very satisfactorily with spinal anesthesia. The Trendelenburg position, which is used in the majority of these operations, offers some difficulties to safe anesthetization and is responsible for some objectionable features, such as a high percentage of vomiting, respiratory failure and collapse.

Spinal anesthesia does not seem to be sufficiently satisfactory for operations on the upper abdomen and thorax to warrant its general use here. When there are contraindications to general anesthesia, or when spinal anesthesia seems to be specially indicated for reasons based on physiologic action, it may be chosen.

Our experience on higher regions of the body is limited to two cases, both of which almost terminated disastrously.

CONCLUSIONS.

IT HAS BEEN our purpose in this paper merely to present in a general way this series of cases without attempting to enter into a discussion of the many important features of spinal anesthesia. Our attitude in regard to the method can be summed up briefly:

It has a restricted field in which it is as safe and as efficient as any general anesthetic, and in addition offers certain advantageous features. It has a wider field in which it can be used satisfactorily and safely when general anesthetics are contraindicated. There are definite contraindications to its use, and disregard of these will certainly lead to unsatisfactory and even disastrous results. Special skill is required for the successful use of spinal anesthesia, particularly in its selective field when it is chosen as the least dangerous anesthetic in desperate cases.

CERTAIN REGULATIONS of penal institutions make it necessary for those in charge of the surgery in prisons to become adepts in the use of spinal anesthesia. In the Journal A. M. A., April 8, 1916, L. L. Stanley of San Quentin, Cal., details a series of almost 300 spinal anesthesias for a great variety of operations on the trunk and lower extremities performed in the California State Prison Hospital. More lately in the California State Journal of Medicine, June, 1919, Stanley reports another series of 300 cases of which some 68 were for conditions which necessitated incisions somewhere below the nipples and above the umbilicus. His carefully kept record and observations are both interesting and instructive and are herewith given in detail:

TECHNIC AND SOLUTIONS.

IN THE CASES in which spinal anesthesia has been used on the inmates at the San Quentin prison, tropacocain has been the agent employed. In ordinary operations, excepting those in which the abdominal viscera are handled, no hypnotic is given the patient before the operation. The patient walks to the operating room, mounts on the table, and is ordered to lie on his left side. The back from the fourth dorsal vertebra to the coccyx is painted over with official tincture of iodin. This is allowed to remain on the skin for a few minutes and is then removed with alcohol. The patient is directed to bring his knees as near to the chin as possible, producing a curved outline to the back. A sterile sheet with an aperture 6 inches in diameter is now placed over the patient so that the hole is near the site of the spinal puncture. A platinum needle of 12 mm. diameter and about 10 cm. long is used for the spinal puncture. The needle is inserted between the second and third, or third and fourth lumbar vertebræ. As soon as the canal is entered, the obturator of the needle is withdrawn and the fluid flows out. Immediately a Luer syringe is attached to the needle, and 25 minims of the cerebrospinal fluid are withdrawn. The syringe is detached from the spinal needle, and by means of a shorter needle the fluid thus collected is used as a solvent for the tropacocain, which is put up in sterile ampules of 1½ grains dosage. While the attendant is dissolving the tropacocain in the cerebrospinal fluid, the operator collects from 15 to 25 minims of the fluid for purposes of Wassermann examination. This having been done, a manometer is attached to the spinal needle and the spinal pressure determined. The manometer used is merely a piece of fine bored glass tubing with an elbow arranged so that the tubing extends at right angles upward from the spinal needle. The manometer is graduated, and the pressure is determined by the height to which the fluid ascends in the glass tubing.

The tropacocain having been dissolved in the fluid, the syringe is again attached to the spinal needle. In order to prevent any air entering the spinal canal, it is our custom to pull the piston out slightly before finally injecting the medicated solution. *Since excluding the air in this way, the number of headaches following operation has been greatly reduced.* The solution is injected slowly and the needle is quickly removed. The patient is then ordered to lie on his back. He is then placed in a Trendelenburg position at about 10 to 12 degrees from the horizontal. The head, however, is raised above the shoulders so that although the medicated fluid may gravitate toward the first dorsal vertebra, it will not well ascend toward the vicinity of the bulb.

Within one minute the patient feels that his feet are becoming warm, and he may even feel a tingling sensation in his toes. Within two minutes, sensation is lost about the anus, and as a rule within about four minutes there is such a loss of sensation that operations for hernia may be done without pain. For operations above the umbilicus it is our custom to allow the patient to stay in the Trendelenburg position for six or seven minutes, for apparently it takes this long for the tropacocain to gravitate cephalad to bathe the nerves which supply these segments. For operations about the anus, the average Trendelenburg position has been 1 7/10 minutes, for operations on varicose veins 2 9/10 minutes, for operations on the scrotum 2 4/10 minutes, for hernia 3 1/10 minutes and for gastroenterostomy 4 2/10 minutes.

Tropacocain hydrochlorid in doses of 1½ grains is carefully weighed and put in thoroughly cleaned and dried homeopathic vials, long size. By means of a Bunsen burner the top is then fused so that the drug is sealed in an air tight ampule. These ampules are then sterilized either by boiling or by live steam in an autoclave. Tropacocain is not injured by heat in this manner, and will keep indefinitely without deterioration or loss of anesthetic properties.

CARE DURING OPERATION.

DURING EVERY OPERATION one attendant is assigned to watch the patient, and keep a record of his actions during the proceedings. All phenomena are carefully recorded chronologically, and remarks regarding the attitude of the patients are set down. In this series of cases the same man has done the recording so that there has been no variation, as would be expected had several operators kept the records.

The following is an illustration of a written operation record:

P., No. 28977, man, age 31, weight 147, logger.

INGUINAL HERNIA, DOUBLE.

Jan. 12, 12:15 p. m.	Blood pressure: 110, systolic; 80, diastolic.
12:16 p. m.	Pulse rate, 72.
1:39 p. m.	Anesthetic administered, tropacocain 1½ grains, 2-3 lumbar.
1:39 p. m.	Head lowered; Trendelenburg position.
1:42 p. m.	Head raised; operation begun.
1:43 p. m.	Pulse rate, 126; could not move feet.
1:48 p. m.	Pulse rate, 96.
1:52 p. m.	Blood pressure: 130, systolic; 76, diastolic.
1:54 p. m.	Pulse rate, 90.
2:00 p. m.	Pulse rate, 84.
2:05 p. m.	Blood pressure: 112, systolic; 80, diastolic.
2:06 p. m.	Pulse rate, 90.
2:11 p. m.	Pulse rate, 90.
2:12 p. m.	Blood pressure: 124, systolic; 80, diastolic.
2:16 p. m.	Pulse rate, 90.
2:23 p. m.	Pulse rate, 80; operation ended. Blood pressure: 124, systolic; 80, diastolic.
3:35 p. m.	Felt first pain and could move feet.
7:15 p. m.	Blood pressure: 108, systolic; 80, diastolic.
Jan. 20, 7:15 p. m.	Blood pressure: 128, systolic; 84, diastolic.

Remarks: Pupils not changed; complexion unchanged; puncture made patient recumbent left side; cord transplanted; pressure (spinal) 15 cm. Left table in good condition. No pain.

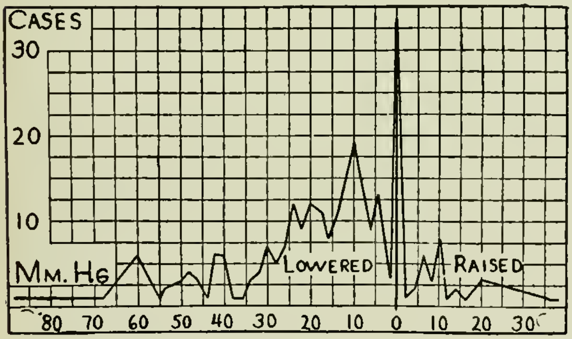
This work was done with the assistance of two former assistant resident physicians, Dr. F. Stolle and Dr. S. H. Marks, and with the present assistant resident physician, Dr. J. P. Crawford.

The accompanying table is a summary of our first series of operations. It is self-explanatory.

BLOOD PRESSURE AND PULSE RATE.

IN THE PLOTTED CURVE of the relative amount of rise or fall in blood pressure at the end of operation, the base line is the amount of blood pressure, and the abscissæ the number of cases. The readings were taken each time with a Tycos sphygmomanometer. It is seen from the chart that the maximum fall in blood pressure was 88, whereas the maximum rise was 38 mm.

In none of these cases, however, was the blood pressure so low that it was necessary to take measures toward increasing it. Although the pressure was low the patient did not show any signs of collapse.



Curve of relative amount of rise or fall in blood pressure at end of operation: readings to left of zero, lowered after operation; to right, raised.

As to pulse rate, it is found that the rate increases as soon as the spinal puncture is made, but after a few minutes returns to the normal beat. This increase is probably due to the fact that the patient is somewhat excited when brought to the operating room. The psychical effect of seeing the operating room attendants and feeling the prick of the spinal needle is sufficient to cause this quickening. From the data it seems that the spinal anesthesia itself has very little if any influence on the pulse.

DURATION OF ANESTHESIA AND AFTER-EFFECTS.

IT IS EXTREMELY DIFFICULT to determine the length of anesthesia because the statements of the patients are not reliable, and it was impossible to determine by means other than their statements regarding this matter. For the purpose of creating sympathy, there is no doubt that some of the patients complained of pain really before it was felt. Only a few, however, complained while they were on the operating table, and it was only necessary in four or five cases of the series in which the operation was over an hour and a half to administer a few whiffs of chloroform or ether to quiet the patient. As near as could be determined, the average length of anesthesia was one hour and fifteen minutes.

Only 8 per cent. complained of headaches. To many surgeons, headache has been the deterring factor for using spinal anesthesia. Some assert that headache is so severe that they will not subject their patients to it. By excluding all air from the spinal canal, however, as shown before, there is very little danger of headache.

Only 18 per cent. had to be catheterized, of which over half were in operations about the anus, in which catheterization is usually expected.

In very few cases after operation has there been any vomiting. It is an extremely rare after-effect. In ordinary cases, such as hernias, varicose veins and other operations in which the intestinal tract is not involved, the patients are allowed to eat as soon as they return from the operating room. No ill results have followed. The food is usually relished. By the early taking of nourishment in this way, shock is reduced and the patient's convalescence is shortened.

The preparation is the same as that usually given for the inhalent anesthetics. No hypnotic is given except as previously noted above.

In only two cases out of a possible 400 has it been found impossible to produce spinal anesthesia. One patient was a woman, aged 90, suffering from hemorrhoids. She was deaf, and it was impossible to instruct her to the best position she should attain. Several attempts were made to enter the spinal canal, but the vertebræ were so ankylosed that it was impossible. In another case, a Mexican, aged 25, was stabbed through the abdominal wall into the stomach so that his recently ingested stomach contents were voided through the opening. He was brought to the hospital thirty minutes after the affray, but was in a condition of shock, and his blood pressure was very low. The puncture was made, and 10 minims of cerebrospinal fluid removed. No more could be withdrawn. On account of the small amount of fluid, it was thought well not to administer the anesthetic. In several other cases it has been found necessary after a delay of ten minutes to make another puncture and inject more of the tropacocain. The failure of the first injection was probably due to the fact that the needle may have been accidentally pulled from out the canal and the tropacocain infiltrated around the dura instead of in the canal. Invariably after the second injection the anesthesia has been satisfactorily produced.

SUMMARY OF OPERATIONS.

	Operations on Feet.	Varicose Veins.	Various Operations on Legs.	Fistula in Ano.	Hemorrhoids.	Operation on Scrotum.	Hernia.	Appendectomy.	Gastro-enterostomy.	Totals.
Cases, number	15	23	18	29	59	30	61	32	13	280
Fall in blood pressure, number	7	22	11	19	31	19	56	25	9	199, 71.1%
Rise in blood pressure, number	5	0	4	3	14	3	2	1	2	34, 12.1%
No change in blood pressure, number	1	1	2	7	13	5	1	3	1	34, 12.1%
No data on blood pressure, number	2	0	1	0	1	3	2	3	1	13, 4.7%
Maximum fall in blood pressure, mm.	60	46	50	50	42	54	88	68	48	88
Minimum fall in blood pressure, mm.	2	8	2	4	4	6	6	2	16	2
Average fall in blood pressure, mm.	27	23	9	9	5	13	22	21	15	15
Maximum rise in blood pressure, mm.	19	0	8	36	38	16	20	20	10	38
Minimum rise in blood pressure, mm.	2	0	6	4	6	5	10	20	10	2
Average blood pressure	125	116	117	114	115	115	119	118	118	117
Average spinal pressure	14	11.5	14	17	12.5	18	14.5	16	14	14.2
Average length of operation, minutes.	33	26	18	18	15	17	35	50	77	28
Average length of anesthesia, minutes.	33	61	70	63	75	70	74	107	?	75
Average age, years	39	42	36	31	38	32	30	31	33	34
Average weight, pounds	150	146	159	161	176	162	170	155	159	160
Headaches	2	8	0	0	7	1	3	2	1	24, 8%
Catheterized	2	0	3	4	27	0	4	12	4	52, 18%
Average Trendelenburg position, min.	3.5	2.5	2.8	1.7	1.7	2.4	3.1	3.2	4.2	2.5

CONCLUSIONS.

1. In this series of 280 cases there has been no fatality.

2. There has been comparatively little shock.

3. There has been only 8 per cent. headaches.

4. There has been no pneumonia following operation.

5. There have been very few postoperative complications.

6. There have been no permanent paralyses following the anesthetic.

7. The period of convalescence has been shortened.

8. With the relaxed muscles, closing of the abdomen is greatly facilitated.

9. The blood pressure has fallen in most cases, but in the average case not to a dangerous degree.

10. The height to which the anesthetic is effective is influenced by the length of time the patient is in the Trendelenburg position.

11. The pulse rate is not influenced to any marked degree by tropacocain intraspinally.

OPERATIONS IN THE UPPER ABDOMEN UNDER SPINAL ANESTHESIA.

WHILE DURING THE past four years spinal anesthesia has been used almost exclusively in all operations *below the nipple line,* on inmates of the California State prison at San Quentin, and during this time about 600 operations have now been performed, only 68 were for conditions which necessitated incisions somewhere below the nipples and above the umbilicus.

These higher operations were not attempted until after it had been satisfactorily demonstrated that spinal anesthesia induced by tropacocain was entirely efficient in hernias, appendectomies, and other surgical procedures of the lower abdomen and lower extremities. The operations which have now been performed with this method of anesthesia are:

Appendectomies, acute and chronic	69
Fistula in ano	58
Hemorrhoids	99
Hernia	147
Varicose veins	40
Various operations on legs and thighs	36
Urethral strictures	28
Operations on scrotum	59
Gastroenterostomy	47
Splenectomy	2
Exploratory laparotomy, upper	7
Excision gastric ulcer	1
Cholecystotomy	1
Cholecystenterostomy	1
Finney's pyloroplasty	2
Hernia, epigastric, recurrent	5
Volvulus	1
Total	603

By reasoning that the tropacocain solution having a specific gravity of 1027 in cerebrospinal fluid with a gravity of 1007, would be influenced by the difference in weight, it was believed that by placing the patient in a slightly inclined Trendelenburg position, the fluid would go toward the head and produce anesthesia in the upper segments. This was demonstrated on a number of patients on whom operations below the level of the umbilicus were performed. The sensations were tested and found to be abolished in the epigastrium, to the level of the nipples, and sometimes even in the arms and hands subsequent to the production of anesthesia in the lower segments, when the body was placed at an angle of 10 to 12 degress to the horizontal. The fluid had, in descending toward the head, bathed the dorsal nerve roots and produced in them the loss of sensation.

The gravitation of the fluid was also demonstrated in a still warm cadaver, thirty minutes after legal execution by hanging. Twenty-five minims of cerebrospinal fluid were withdrawn from the spinal canal. Into this was dissolved one and one-half grains of tropacocain, together with a few drops of methylene blue. After this was reinjected into the spinal canal, the body was placed with the pelvis slightly elevated for five or six minutes. On rhachiotomy it was shown that the spinal cord tissues were stained as high up as the fourth dorsal vertebra from which emerges the fourth nerve supplying the region about the nipples.

OVERCOMING DIFFICULTIES

THE FIRST UPPER ABDOMINAL OPERATIONS performed here in 1914, were not satisfactory. It was found that the blood pressure in a few cases fell quite low, that the patient was frightened, that the anesthesia did not last long enough, and that there was some discomfort when the stomach was handled. Later on these difficulties were remedied.

The blood pressure was taken every five minutes and carefully recorded. If it were found greatly reduced, four or five drops of adrenalin in normal salt were given subcutaneously, with very quick response. Only in rare cases, however, did the fall in blood pressure cause alarm.

It had been the custom to operate on these cases without previously giving an opiate, and whereas many were able to control their temerity, it was considered best to administer ¼ gr. morphin and 1/160 atropin, half an hour before commencing to operate. In this way it was found that the patient came to the operating room with his fears allayed, and in many cases, slept during the whole operation.

The sensibilities were so dulled by the opiate that the conversation of the attendants or the click of the instruments did not produce fear or excitement. After the anesthetic was administered, the patient was placed on his back, and a moist towel placed over his eyes to exclude light.

With an injection of 1½ gr. of tropacocain, it was found that the anesthesia lasted less length of time than with three grains. With the former dosage the time was about 1′ 45″ The larger dose did not produce any ill effects and was well stood by the patient. In the earlier cases when 1½ grs. were used, the anesthetic wore off before the operation could be completed, and it became necessary in some of these cases to finish with ether. This procedure, even so, is not at all bad, for the small amount of ether necessary to complete the operation tends to bring the blood pressure back to normal. Administering the ether is not difficult, for with the spinal anesthetic, the patient cannot move, and the surgeon may continue with his work unmolested while the inhalant is being given. It is not often necessary to finish with the ether, for most of the upper abdominal operations can be completed before the effect of the tropacocain subsides.

After injecting the anesthetic solution into the spinal canal, four or five minutes elapse before the epigastrium desensitized. In order to spare these few minutes the site of the operation is quickly prepared with sterile towels, and a few cc. of 0.5 per cent. novocain solution are injected under the skin in the line of incision. By this method, the abdomen can be opened, and by the time the viscera are reached, the whole region is well anesthetized. This procedure is not necessary except as a saving of a little time.

ADVANTAGES.

IN FIFTY-TWO of these upper abdominal operations, the blood pressure fell, the greatest drop being 76 mm. and the least 2 mm., with an average fall of 28 mm. These changes were based on the record of the pressure before the operation began, and on that at the end before the patient left the operating room.

In three cases there was no change in pressure, and in six the blood pressure was higher at the end of the operation than before.

The use of spinal anesthesia in upper abdominal surgery is a distinct advantage over the inhalants. Anesthesia is more quickly induced. Within five minutes after the patient comes to the operating table the operation may be begun. No anesthetist is needed, the surgeon himself giving the spinal injection. A nurse or attendant should be on hand, however, to note pulse and respiration.

The abdominal walls are thoroughly relaxed, and sewing up is a very simple matter. There is very little shock because the spinal cord is temporarily blocked by the anesthetic, and no harmful impulses reach the brain. There is seldom any vomiting, except what might be expected after a gastroenterostomy. No foreign substance is secreted in the stomach to produce emesis. No pneumonias follow this anesthetic, for the lungs are in no way affected. There have been no bad results following the spinal anesthesia as used here.

POSTOPERATIVE ALKALOIDAL ANALGESIA . OBVIATING PSYCHIC TRAUMA . ROLE OF SCOPOLAMIN-MORPHIN . DOSAGE . GRAPHIC PRESENTATION . RESULTS AT THE MARY THOMPSON AND COOK COUNTY HOSPITALS . RELATION OF OPERATION TO POSTOPERATIVE PAIN . OTHER FACTORS CONTRIBUTING TO PERFECTED ANALGESIA . CONCLUSIONS . OBVIATING FEAR .

BERTHA VAN HOOSEN, M. D. LOYOLA UNIVERSITY CHICAGO, ILLINOIS.

PAINLESS CONVALESCENCE presupposes surgical preparedness It is also an obvious factor in eliminating the fear of operation. Bertha Van Hoosen of Chicago, Ill., using the clinics of the Mary Thompson and Cook County Hospitals has devised a method of postoperative analgesia based on the administration of small doses of scopolamin-morphin every four hours to assure a painless recovery period from surgical operations. Speaking before the Joint Session of the Interstate Association of Anesthetists and the American Association of Gynecologists and Obstetricians in Cincinnati, September 15-17, 1919, Bertha Van Hoosen outlined her methods as follows:

Postoperative analgesia means a painless convalescence for surgical patients. Attention to every detail before, during, and after operation, especially from the standpoint of pain production, will develop an analgesic technic which will reward the surgeon for his time and trouble. This technic should be directed toward the prevention rather than the relief of pain. It should include the avoidance of psychic trauma previous to operation, and tissue trauma during operation. Gas pains, thirst, emesis, and catheterization must cease being necessary certainties and become avoidable and infrequent occurences.

AVOIDING PSYCHIC AND OPERATIVE TRAUMA.

THE FIRST STEP in the technic should be to prevent psychic trauma before operation. This is done by informing the patient that when she goes to the hospital the afternoon previous to operation that she will have a blood and urine examination, a liquid supper and a thorough flushing of the bowel in the evening. Very early the next morning the nurse will give a hypodermic injection and another an hour later. After the second injection she will sleep so soundly that she will not know or care when she is taken on a cart to the operating room and prepared for the operation; that the operation will be performed and she will be taken back to her room and will continue to sleep for several hours. When she awakens she will be so free from pain that it will be difficult to believe the nurse who says that the operation is over.

In more technical language the surgeon will use scopolamin-morphin anesthesia, no catharsis before or during the week following operation, and that all preparation of the field of operation, including catheterization will be done in the operating suite one-half hour after the second hypodermic injection of scopolamin-morphin.

UTILITY AND DOSAGE OF SCOPOLAMIN-MORPHIN.

SCOPOLAMIN-MORPHIN is the only anesthetic that gives you a perfect means of preventing psychic trauma previous to operation, and unlike any other anesthetic it is followed by a period of analgesia varying from eight to twelve hours after consciousness has been regained.

It may be desirable to continue the analgesia for a longer time. If so, it can be done by prescribing scopolamin $\frac{1}{200}$ grain with morphin $\frac{1}{32}$ grain, or scopolamin $\frac{1}{400}$ grain with morphin $\frac{1}{64}$ grain every four hours beginning about four hours after the operation and continuing for 24, 36 or 48 hours according to the probable length of the period of postoperative pain. Convenient hours for giving this postoperative Twilight Sleep (for that is really the condition produced) are 12-4-8 A. M. and P. M.

The production of and the relation between the anesthesia and the analgesia obtained by the administration of scopolamin with morphin is more graphically presented by a diagram.

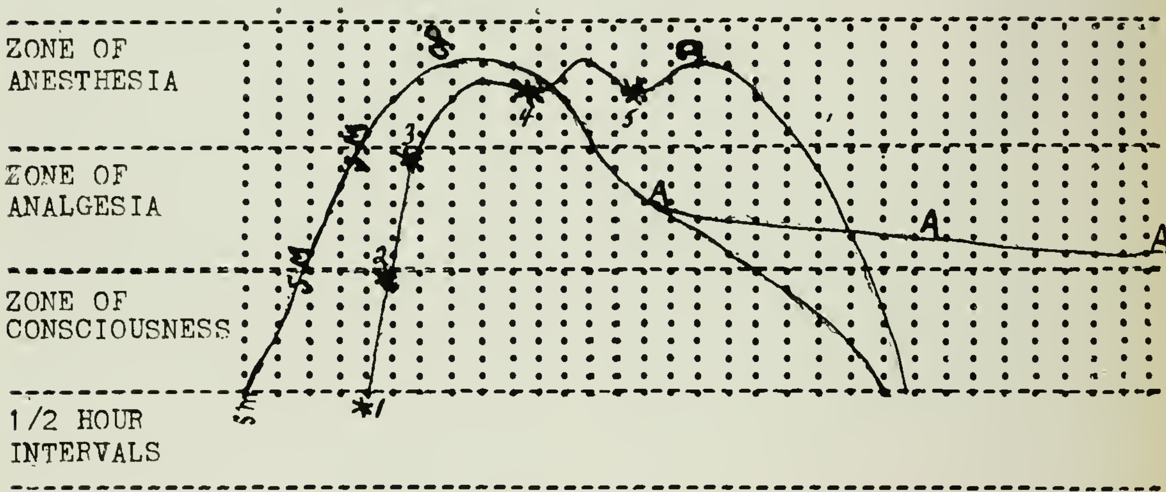
RESULTS.

THE RESULT OF this treatment may be studied from the report of 452 cases prepared by my assistant, Dr. Martha Welpton from the records of patients in the Cook County and Mary Thompson Hospitals during the year 1916.

Under *Sleep* the cases are listed as slept well, fairly well, or poor. The first and second nights are given separately.

Pain—anything which might cause patient to complain, as gas, headache, or wound.

SCOPOLAMIN-MORPHIN IN RELATION TO ANESTHESIA AND ANALGESIA.



SM indicates the preliminary doses of scopolamin 1/100 gr., and morphin ¼ gr, before surgical operation.
* 1 indicates the first dose of scopolamin 1/100 gr., and morphin ⅛ gr., in obstetrics.
* 2, 3, 4, and 5 indicate succeeding doses of scopolamin 1/100 gr., in obstetrics.
A indicates scopolamin 1/200 gr., and morphin 1/32 gr., in 4 hourly dosage for postoperative analgesia.
Op indicates operation. D indicates delivery.

To avoid mistakes or confusion where a number of patients are receiving this treatment the doses for all patients should fall on the same hour, and as the patients are more quiet just after the hypodermic injection and more wakeful just preceding the hours above mentioned were selected so that the patients might be sleeping during the serving of dinner and supper and during the hours of morning ward work, and awake during visiting hours from 2 to 4 and 7 to 8 P. M.

Emesis covers any nausea or vomiting during the first two days, even though it were but a mouthful, and but once.

Respiration shows a record of respiration under sixteen during the first twenty-four hours. None was found during the second twenty-four hours.

Pulse shows a record of pulse above 100 during the first twenty-four hours.

MARY THOMPSON HOSPITAL.

Two hundred consecutive cases operated and given postoperative doses of morphin 1/32, scopolamin 1/200, for from twelve to forty-eight hours. Thirty-six hours, or until midnight of the second day, was the usual time.

	SLEEP						
	Poor	Fair	Well	Pain	Emesis	Respiration	Pulse
1st night	28	107	65	46	77	62	99
2nd night	15	82	101				
					Percentage.		
1st night	14	53.5	32	23	38.5	31	45.5
2nd night	8	41	50.5				

COOK COUNTY HOSPITAL.

Two hundred and fifty-two consecutive cases operated and given postoperative doses of morphin 1/32, scopolamin 1/400 for from twelve to forty-eight hours. Thirty-six hours, or until midnight of the second day, was the usual time.

Patients at the County Hospital were given the postoperative dose of scopolamin 1/200 and morphin 1/32, but it was soon discontinued and scopolamin 1/400 was substituted for the 1/200 on account of the patient occasionally getting out of bed or showing signs of mild delirium, and thereby requiring extra attention from the nurses.

	SLEEP						
	Poor	Fair	Well	Pain	Emesis	Respiration	Pulse
1st night	40	106	108	33	93	4	136
2nd night	20	87	145				
				Percentage			
1st night	15.4	42.6	42.6	13	37	1.5	53.9
2nd night	7.7	34.5	57.8				

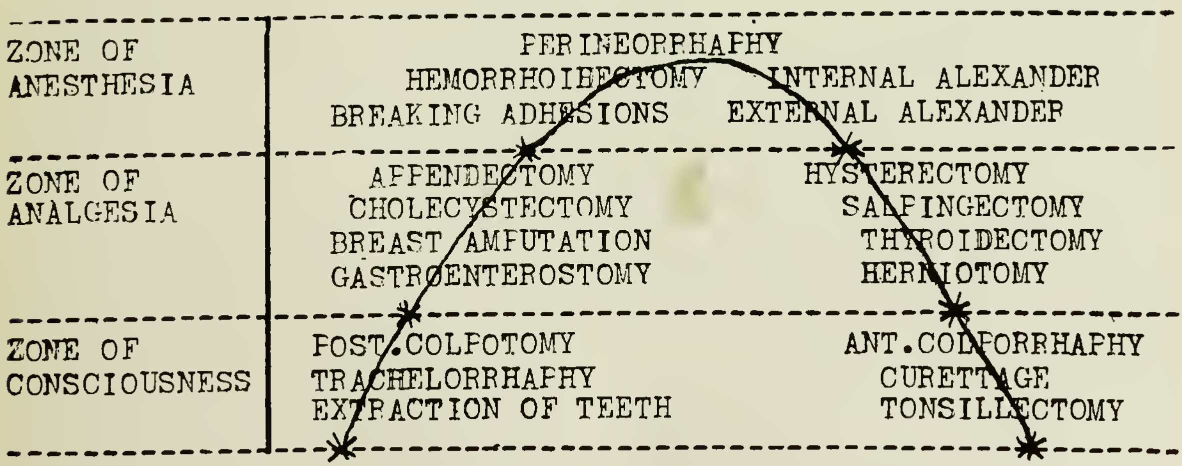
RELATION OF OPERATION TO POSTOPERATIVE PAIN.

A MISTAKEN IDEA of the degree of anesthesia or analgesia that has been produced can be gotten by failing to recognize the differences in regional anesthesia.

The following chart gives the relative position of various operations in regard to the production of pain during operation and postoperative pain.

Perineorrhaphy and hemorrhoidectomy requiring full doses scopolamin-morphin and additional chloroform or ether head the list, while

SURGICAL PROCEDURES IN RELATION TO OPERATIVE AND POSTOPERATIVE PAIN



extraction of teeth and operations on the cervix uteri can be done painlessly with so small a dose of scopolamin-morphin that the patient will not lose consciousness.

OTHER FACTORS CONTRIBUTING TO PERFECTED ANALGESIA.

ANALGESIA TECHNIC must include attention for the relief of gas pains, the relief of thirst, and avoidance of catheterization. Fortunately a simple procedure, namely, the employment of very large enamata to be retained will control perfectly each one of these symptomatic conditions.

While the patient is on the operating table and the abdomen is being closed an enema of two quarts of water containing 360 grains of soda-bicarbonate is rapidly (average time 2 minutes) introduced into the bowel through a colon tube inserted into the rectum not farther than three inches. This 2 quart enema is retained by all patients except hemorrhoidectomies and some thyroidectomies. After the patient has been taken to her room and is comfortable in bed which is approximately 20 minutes after the 2 quart enema was given, another enema of 2 or 3 quarts with or without the addition of soda is given, but a little more slowly (average time 10 to 15 minutes). This enema is likewise retained, never being passed by the bowel but is taken up by the circulation and returned by the kidneys, skin and lungs.

Pain in the wound itself, which should be inappreciable, is often augmented by the rough handling of the tissues especially by blunt dissection and by excessive sponging during the operation. The "clean field" method which calls for constant sponging of the incised parts not only requires a deeper anesthesia but exacts a maximum loss of blood by preventing coagulation and it also exposes the cut surfaces to the irritation of the air instead of allowing them the natural protection of oozing blood.

Even the position in which the patient is placed after operation plays a part in the relief or production of pain. For every pain in the body there is a posture that the patient involuntarily assumes to obtain relief. The characteristic posture to relieve abdominal pain is an approximation of the chest and knees thus relaxing the abdominal muscles. To secure this posture for the patient who has had an abdominal operation, elevate the upper part of the body with the bed rest or pillows and place a roll under the knees. The universal practice of discarding the pillow as a post-anesthetic measure can in no way add to the comfort of the patient, but, on the contrary may in some cases provoke vomiting or emphasize discomfort.

CONCLUSIONS.

TO ENUMERATE THE factors in post-operative analgesia technic in order of their importance:

1. Scopolamin-morphin anesthesia.
2. Large enemata (4 to 5 quarts) given in one-half hour following operation and retained.
3. Frequent minute doses of scopolamin-morphin at regular intervals after operation and continued for the first 24 or 36 hours.
4. The use of sharp instruments during the operation, avoiding blunt dissection.
5. Sponging gently and infrequently.
6. A comfortable posture for the patient, with an effort to secure relaxation or support as may be required for the traumatized part of the body.

OBVIATING THE FEAR OF OPERATION.

THE FEAR OF OPERATION which so often causes the patient to seek surgical aid too late is a testimonial to the little attention surgeons have bestowed on this subject; nevertheless it is well worth an effort. By instituting analgesic technic the old laborious, worrisome first two days after the operation will be transformed into a much needed rest and quiet. The hospital will be free from the odor of ether, enemata and vomitus, the groans of suffering patients, the frequent ringing of bells and the insistent demands for something to relieve thirst. When patients are comfortable or sleeping relatives will willingly refrain from long and frequent visits. Internes will not be wakened at night by nervous and restless sufferers and the surgeons will have patients who no longer look upon an operation with dread and terror, but who will encourage their friends to take advantage of a cure by painless surgery.

Painless convalescence presupposes surgical preparedness, and surgical preparedness like national preparedness insures either peace or easy victory.

BEFÓRE EACH OF US IS THE PROSPECT OF OUR AMBITION. IT IS OUR BIRTHRIGHT. IT PROVES OUR WORTH AND OUR POSITION. IT IS THE TEST OF OUR GREATNESS. AMBITION IS AS ESSENTIAL TO ACHIEVEMENT AS POWER IS TO MECHANICAL OPERATION. TO ALL THOSE WITH PRIDE IN PROGRESS IT IS A FORCE MORE INSISTENT THAN NECESSITY. THE BUILDING OF NATIONS, THE CULTIVATION AND UNIFICATION OF PATRIOTIC IDEALS, THE ADVANCEMENT OF MANKIND, THE CONTRIBUTIONS OF ART AND SCIENCE, THE INCREASE IN INDUSTRIAL EFFECTIVENESS; ALL THESE COME IN ANSWER TO THE CALL OF AMBITION. IN AN EFFORT TO INCREASE THE STRENGTH AND VALUE OF COORDINATING INTERESTS MEN HAVE SOUGHT OUT A MEANS WHEREBY ALL THE PUBLIC COULD BE MADE FAMILIAR WITH THE WAYS AND PRODUCTS AND RESULTS OF ART, SCIENCE AND BUSINESS. THE EFFORT RESULTED IN THE RECOGNITION OF THE EDUCATIONAL FORCE TERMED PUBLICITY. BECAUSE OF ITS CAPACITY FOR SHOWING RESULTS PUBLICITY HAS BECOME THE MOST HIGHLY DEVELOPED EXPRESSION OF AN AMBITION TO SERVE VAST INTERESTS AND TERRITORIES THAT HAS YET BEEN MADE OPERATIVE.

—*N. Ayer.*

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THE SURGICAL CLINICS OF THE ALEXIAN BROTHERS HOSPITAL, CHICAGO; BOSTON CITY HOSPITAL; CALIFORNIA STATE PRISON HOSPITAL; COOK COUNTY HOSPITAL; CRAIG COLONY FOR EPILEPTICS; DENTAL DEPARTMENT DETROIT BOARD OF HEALTH; EVANS MEMORIAL DENTAL INSTITUTE; EVANSTON MATERNITY HOSPITAL; FIRST LONDON GENERAL HOSPITAL; GUY'S HOSPITAL; LENNOX HILL HOSPITAL; LORD DERBY WAR HOSPITAL; LAKESIDE HOSPITAL AND UNIT A. E. F.; LANKENAU HOSPITAL; LONG ISLAND MEDICAL COLLEGE HOSPITAL; MASSACHUSETTS GENERAL HOSPITAL; MAYO CLINIC; MARY THOMPSON HOSPITAL; MCGILL UNIVERSITY HOSPITAL UNIT; NEW JERSEY STATE VILLAGE FOR EPILEPTICS; NEW YORK LUNG, THROAT AND NOSE HOSPITAL; POLYCLINIC HOSPITAL, N. Y.; POST GRADUATE HOSPITAL, N. Y. AND CHICAGO; PRESBYTERIAN HOSPITAL; QUEEN ALEXANDRA'S HOSPITAL FOR OFFICERS; ROBERT PACKER HOSPITAL; SANTO THOMAS HOSPITAL; TORONTO GENERAL HOSPITAL; VITTEL HOSPITAL CENTER A. E. F. AND FRANCES WILLARD HOSPITAL.

AMERICAN JOURNALS OF SURGERY, CLINICAL MEDICINE, PHYSIOLOGY AND OBSTETRICS; ANNALS OF SURGERY; BOSTON MEDICAL AND SURGICAL JOURNAL; BRITISH MEDICAL JOURNAL; CALIFORNIA STATE JOURNAL OF MEDICINE; DENTAL COSMOS; DENTAL OUTLOOK; DENTAL REVIEW OF REVIEWS; DENTAL SUMMARY; GUY'S HOSPITAL REPORTS; INTERNATIONAL JOURNAL OF ORTHODONTIA; INTERSTATE MEDICAL JOURNAL; JOURNALS OF THE AMERICAN MEDICAL ASSOCIATION, EXPERIMENTAL MEDICINE, CANADIAN MEDICAL ASSOCIATION, BIOLOGICAL CHEMISTRY, PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS, LABORATORY AND CLINICAL MEDICINE, AND NATIONAL DENTAL ASSOCIATION; JOURNAL-LANCET; LONDON LANCET; LENNOX; LARYNGOSCOPE; MEDICINE AND SURGERY; NEW YORK MEDICAL JOURNAL; NEW ORLEANS MEDICAL AND SURGICAL JOURNAL; PROGRES MEDICAL; PENNSYLVANIA MEDICAL JOURNAL; SURGERY, GYNECOLOGY AND OBSTETRICS; SURGICAL CLINICS OF CHICAGO, THERAPEUTIC GAZETTE, UROLOGIC AND CUTANEOUS REVIEW AND TRANSACTIONS ROYAL SOCIETY OF MEDICINE, SECTION OF ANESTHETICS.

1917 . AN INDEX OF THE CURRENT LITERATURE OF ANESTHESIA . 1918

This Index, covering the important papers published in the Medical and Dental Journals during 1917-18, has been compiled from the Quarterly Index of the American Journal of Surgery, Anesthesia Supplement, and arranged under such phases of anesthesia and analgesia as will enable the Year-Book reader to exhaust the current references of any pertinent subject, which he may wish to investigate or study . Reprints of pertinent papers are desired for indexing.—The Editor.

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Spinal Anesthesia, Treatment of Sciatica by. C. Mancini. Riforma Medica, June 1, 1918.

1917 . INDEX OF THE CONTENTS OF VOLUME TWO . 1918

1917 . INDEX TO ADVERTISERS AND PERTINENT PRODUCTS . 1918

THE articles presented in the advertising section of this Year-Book are those products or appliances that are especially applicable, in fact, quite necessary in the science and practice of Anesthesia and Analgesia. The well-known reputation and standing of the firms presenting them for consideration, are sufficient guarantees of their value and utility.

MEDICINAL PRODUCTS.

APPARATUS.

The SUPERIOR VALUE *of* NITROUS OXID-OXYGEN ANESTHESIA & ANALGESIA *for* ANESTHETISTS, SURGEONS, DENTISTS & ALL SPECIALISTS

NITROUS OXID-OXYGEN is the safest, most flexible and satisfactory method of anesthesia and analgesia now in routine use. It is eliminated so rapidly, even after prolonged administration, and has so little effect on the body tissues and functions, that it is the anesthetic of choice in the most hazardous operative risks. It is the only method of anesthesia in which any percentage of oxygen required by the condition of the patients may be given without affecting the efficiency of the narcosis. Patients find it so pleasant to take and so comfortable to recover from that they now demand its beneficence and pay good fees for its use.

ANESTHETISTS now realize that nitrous oxid-oxygen anesthesia and analgesia enable them to bring to the practice of their specialty a measure of competence that makes them vital members of the surgical team. The method is so flexible that anesthetists have equally at their command intermittent or continuous analgesia with conscious cooperation of the patient or surgical narcosis with any desirable degree of relaxation by means of primary and secondary saturation. Also the signs of anesthesia and the blood pressure guides under nitrous oxid-oxygen have been so accurately charted that anesthetists can keep themselves and their operators absolutely informed as to the patient's condition during every moment of an operation. Nitrous oxid-oxygen is applicable to all the routine operations of general surgery and may be given by a variety of methods necessitated by the exigencies of operative procedures in the specialties.

PROVIDENCE, R. I.

The most valuable feature of the GWATHMEY APPARATUS seems to me to be its simplicity. Because of absence of complications it is not likely to get out of order and is readily understood by the beginner. The least satisfactory feature is the casters on which it is mounted which always interfere with readily moving it about the hositpal when the cylinders are attached.

ROCHESTER, N. Y.

As I do not take anything back that I have said about your apparatus—all of which was said after having experience with three others that are still on the market—I see no reason why you should not have the privilege of using it with or without my name.

As to the least satisfactory feature, other than a more flexible face piece (a fault that is common to all, and which I suppose will some day be invented) the only feature that I should consider unsatisfactory is the inability to deliver pure oxygen at once to the subject. Of course, this is not so important after one has had experience, but I have always said that, for this reason, I consider it a poor one for a beginner in gas and oxygen work.

Of all things it stands up, and my hat is off to the inventor of the controls, for they have never frozen on me, and if there is a diaphragm in them, I have never seen it. And at present prices for gas, the economy is no small item.

WYOMING, OHIO

I consider the sight feed to be the most satisfactory feature and the ether attachment to be the most unsatisfactory. The latter is open to the same criticism as practically all the ether attachments that I know of, so it is not a very serious criticism after all.

FAIRMONT, W. VA.

To me, as an anesthetist, the most satisfactory thing is the sight feed. You can see your proportions and not guess at them. Another great point in its favor is, that it seldom ever gets out of order, is always ready for use. Its economy and simplicity are two more points worthy of mention, and last but not least, I consider it the most efficient machine I have used. It is so constructed that you can use singly or in sequence nearly all the anesthetic agents that are used today, and one can make use of either the closed or semi-open vapor method—a decided advantage in apparatus.

One of the unsatisfactory features of the Gwathmey Apparatus, at times, especially when the head has to be turned to the side, is the "expiratory valve" in your face mask—it sticks, and does not open and close properly, allowing too much air to get into the mixture—at times I have had to tap it and use pins to get this valve working right.

LOUISVILLE, KY.

The most satisfactory feature of the GWATHMEY APPARATUS? My answer would be: Its simplicity. For it is simple to understand and simple to operate.

The least satisfactory feature? The inability to change from gas ether to air and ether without change of mask.

BOSTON, MASS.

Most satisfactory—Simplicity.

Most unsatisfactory—Inability to replace empty tanks while gas from that side is flowing. Not quite as strongly built as it should be for the hard use I give it.

EAST ST. LOUIS, ILL.

It is not a hard matter to tell you what I consider the most satisfactory feature of the GWATHMEY, and as I have never been able to find any kind of fault it would be impossible for me to answer the second, reasonably speaking.

The good qualities I consider: simplicity, durability, economy of gases, sight feed permitting of known mixtures thereby assisting in the scientific application of the anesthetic vapors, light and compact making it easy to move about. The close proximity of the rebreathing bag to face piece. The fact that frozen cylinders are practically unknown.

NEW YORK CITY

1. Low pressure delivery of gas and oxygen with sight feed thru a liquid medium.
2. Its general simplicity, freedom from repair and its dependability.
3. The individual valve for each cylinder, making it very economical.
4. It readily permits the attachment of many special devices to suit the individual taste.

DENVER, COLO.

You surely can use my letter in any way you like.

I am not using the S. S. White machine. All that I am using of theirs is their large reducing valves or indicators.

I am using both the Heidbrink and Teter machines for my extraction work here in the office.

I use the portable Gwathmey that you made up for me for all my major surgery at the hospitals.

Its points of superiority over the other machines on the market are: That it is light and compact, and is carried in an ordinary obstetrical bag. Can be quickly assembled and is simple to operate. The whole apparatus weighing less than a pair of large tank gauges, which is necessary equipment for all other apparatus on the market. **The outstanding feature of the Gwathmey is the fact that there is absolutely no freezing of the valves and one is sure that there will be no interruption of the operation.**

BOSTON, MASS.

The most satisfactory feature I consider is its simplicity and the least satisfactory feature the lack of a valve to hold the gas while a tank is changed. This of course is corrected in your last large model.

BUFFALO, N. Y.

In my experience the outstanding feature of the GWATHMEY APPARATUS (way beyond any others I have seen) is its wonderfully simple construction and operation, while the least satisfactory feature is the rather slow response when an increased amount of oxygen is desired immediately.

PHILADELPHIA, PA.

The simplicity of the whole apparatus is one feature that commends itself to a great many men, and the sight feed is another of its advantageous features, especially for teaching purposes.

It is also readily adapted to open forms of anesthesia.

There is only one feature that I would like to see changed and that is some arrangement whereby an immediate supply of oxygen could be obtained with a minimum of manipulation.

LOUISVILLE, KY.

You have my permission to use my name for I have the greatest confidence in the Gwathmey apparatus.

The bad features: (1) The danger of breaking the glass. (2) The possibility to leak around the sight feed. (3) The inability to use extra tall cylinders.

The best features: (1) Simplicity. (2) Economic use of gas and oxygen. (3) Reliable.

THE FOREGGER COMPANY
47 West 42nd Street
New York City

A NEW DU PONT ETHER *for* OBSTETRICAL ANALGESIA

FURTHER STUDIES OF THE ETHER, by Cotton and others, have shown that it possessses the very desirable property of producing a controllable state of analgesia, sufficient for certain operations of minor surgery, dentistry and obstetrical pain relief, without the loss of consciouness or co-operation by the patient. The theory of this ether analgesia is based on the fact that on account of the boiling point of absolute ether, it is possible to produce an ether vapor-tension in the tissue locally, at the point of maximum heat production, which is in the end of the capillaries of the peripheral tissues. An initial vasodilatation caused by the ether, allows for a saturation of the tissues, while a subsequent vaso-constriction maintains the ether vapor-tension and the analgesia. These phenomena also account for the stabilization of pulse rate and blood pressure during analgesia and anesthesia under Cotton Process ether.

COTTON PROCESS ETHER is especially valuable for vapor anesthesia in oral surgery, as its potency and flexibility admit of conserving the protective throat reflexes, while providing any required pain-relief. Also the new ether may be used with entire satisfaction in the combined method of anocithesia, with local or nitrous oxid-oxygen anesthesia and alkaloidal amnesia. Recovery is so rapid that due caution must be taken to continue the administration of the new ether to the conclusion of the operative procedure.

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A NEW DU PONT ETHER *for* COMBINED ANOCITHESIA

ABBOTT'S PROCAINE A-P FOR LOCAL ANESTHESIA

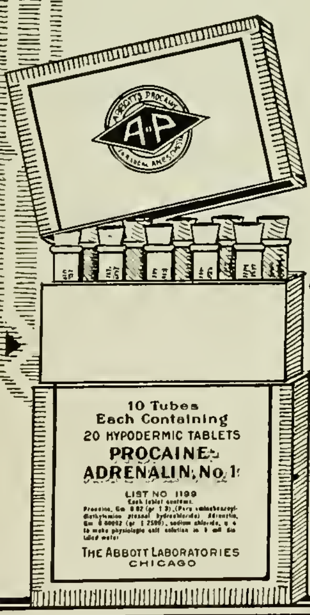
Order By Name-"A-P"-Of Your Dealer

MORE than a quarter of a century of devotion to the highest ideals in manufacturing first quality pharmaceuticals, and a cherished world-wide reputation for purity and accuracy stand behind this American Procaine, made by Abbott. Hunt the world over and you will not find a better Procaine than Abbott's. For short, just call it "A-P" and order by this name. You may use "A-P" with that implicit confidence you feel toward a product into which has been put the best that scientific knowledge and manufacturing skill can produce.

"A-P" No. 1 Procaine—Gm. 0.02 (gr. 1/3).
Adrenalin—Gm. 0.00002 (gr. 1/2500).
Sodium Chloride q.s. to make solution isotonic.

"A-P" No. 2 Procaine—Gm. 0.02 (gr. 1/3).
Adrenalin—Gm. 0.00004 (gr. 1/1500).
Sodium Chloride q.s to make solution isotonic.

Note that these tablets contain Sodium Chloride in sufficient quantity to make the solutions isotonic.



Above are supplied in tubes of 20 tablets packed 10 tubes to the box. Also in bottles of 100 tablets.

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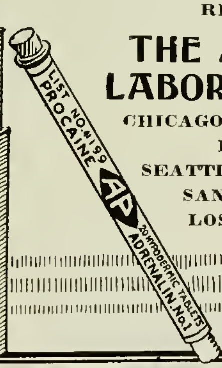

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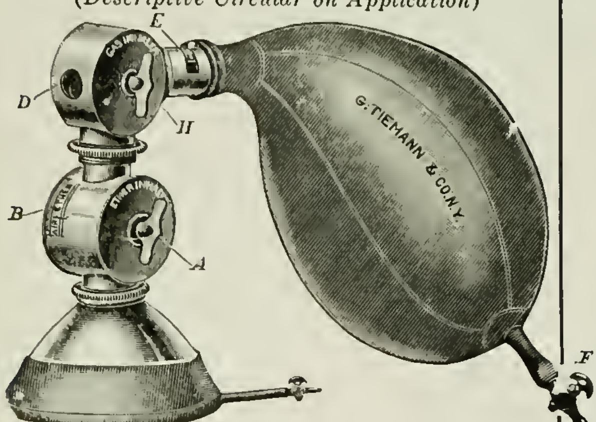
LOOK FOR THE "A-P" BRAND on EVERY TUBE or BOTTLE

The NATIONAL ANESTHESIA RESEARCH SOCIETY, *Inc.*

READERS OF THE YEAR-BOOK will be interested in knowing more about The National Anesthesia Research Society, Inc., so the following details are given regarding its organization, purposes, control and activities:—The Society was organized by forward-looking manufacturers of anesthetics and apparatus to provide a limited financial foundation for the following objects:—(1) To promote the science of anesthesia and to enable the members to submit to the dental and medical professions any views, findings or accomplishments they have attained. (2) To obtain from all available sources information concerning any material, liquid or gas known to have anesthetic properties. (3) To arrange in cooperation with dental, medical and anesthesia associations for the preparation and delivery of suitable, interesting and educational papers on the general subject or relative to some particular anesthetic. (4) To use its influence to avoid the publication or circulation of any false or unauthentic statements concerning the science or practice of anesthesia, or about any anesthetic. (5) To receive and tabulate reports of any and all conditions, symptoms or phenomena prevailing during or after anesthesia by any anesthetic and to prepare and distribute, on request, forms on which such information can be tabulated with uniformity. (6) To distribute by pamphlet or publication, as its funds may permit, such reliable data as may be collected or obtained from those interested in the subject. (7) To aid, as far as possible, in the preparation, publication and sale of suitable text books on the subject of anesthesia, and to prepare as rapidly as possible, reference books for use by the medical and dental professions. (8) To cooperate with the state authorities in the preparation of suitable legislation to safeguard those to whom an anesthetic is to be administered, as well as those called upon to administer it. (9) To arrange for the production of moving picture films to illustrate to the profession the action of anesthetics on the patient during induction and maintenance of anesthesia, and to prepare articles for publication in magazines and the public press. (10) To use its influence in every possible way and to give its aid toward the advancement of the science, practice and teaching of anesthesia. Any individual holding a degree of Doctor of Medicine or Doctor of Dental Surgery from a duly recognized college or university, or a Doctorate of similar standing in Science or Research, shall be eligible for professional membership in this Society. The annual dues are $2.00 payable in advance.



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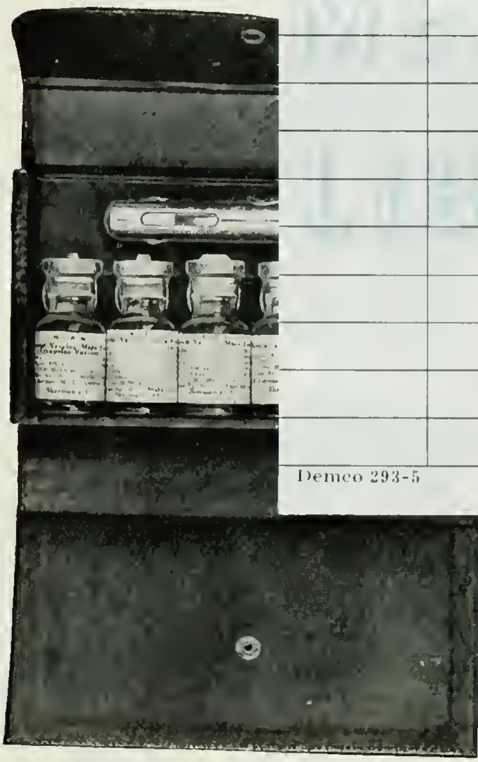

The Sherman Utility Vaccine Case.

TS, suffering from some
er of infection and com-
ration under anesthesia
d for the surgical ordeal
by the use of an appro-
irgeons do not like to
infection if surgical in-
ostponed; and anesthet-
e extra hazard that in-
idministering any anes-
is connection it is only
accines to counteract the
infection and to restore
in some measure the vital resistance of those patients, who, eventually must be operated upon.

Those surgical teams who will give their patients the benefit of vaccine treatment will improve their results remarkably.

WHILE THERE IS a great deal of dispute about the causative factors of postoperative pneumonia, it cannot be denied that many patients present for operation with colds and incipient pulmonary infections and with foul mouths teeming with pneumococci and streptococci. Without vaccine treatment such patients are prone to develop postoperative pneumonia from a variety of causes. Such patients can be protected from pulmonary complications by appropriate inoculations.

G. H. Sherman, M. D. **DETROIT, MICHIGAN.**