**Intravenous anaesthesia / by William Francis Honan and J. Wyllis Hassler.**

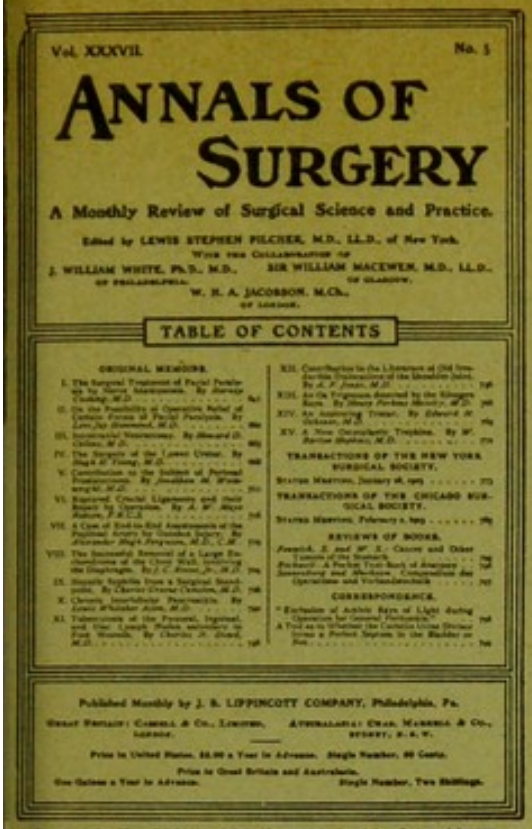
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TABLE OF CONTENTS



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OF NEW YORK,

Surgeon to the Metropolitan Hospital,

AND

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Assistant Surgeon, Metropolitan Hospital.

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# INTRAVENOUS ANÆSTHESIA.*

BY WILLIAM FRANCIS HONAN, M.D.,

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THE exacting demands of both operator and patient in the surgery of the present day have taxed the skill and resources of the expert anæsthetist to the uttermost limits and have caused him to explore all fields which give any promise of anæsthetic possibilities. The layman, with a somewhat exaggerated idea of the safety of modern surgical operations, usually disregards the potential factor of danger present in all operative procedure but invariably seriously considers the probable risk from the administration of an anæsthetic. The surgeon insists upon a period of stable anæsthesia of indefinite duration, with complete relaxation of the musculature of the patient, minimum risk, freedom from postanæsthetic nausea and vomiting, and finally the absence of those more serious complications of the post-operative stage, which are now believed to be the direct result of the narcosis. These post-operative complications, which may be immediate or remote, have been very closely studied and are variously supposed to be the direct irritating effects of the narcotizing agent—in some cases amounting to actual degeneration of tissues with a more or less constant and definite pathological picture. Crile's wonderful observations and experiments, conducted with a scientific acumen and judgment amounting to a veritable inspiration, have set other standards and have established principles that introduce an entirely new era in anæsthesia. He has demonstrated, beyond the shadow of reasonable doubt, that during operations conducted under the usual methods of ordinary inhalation anæsthesia, traumatic impulses from

* Read before the American Association of Anæsthetists, June, 1913.

the operative field are constantly bombarding the cerebrum, that the tissues, nerve tracts and portions of the sensory portion of the brain, are keenly awake and alive to these harmful associations, and that the subjective mind is not narcotized,—only imprisoned. Furthermore, that the involuntary struggles of the patient not deeply anæsthetized, and which have always been considered simply reflex and without importance except to indicate the necessity of more anæsthetic, are in reality motive efforts on the part of the patient to escape the operative trauma, such movements, excited by irritation, being a heritage of experiences from the patient's phylogenetic ancestry.

It has long been known that the vasomotor, cardiac and respiratory centres in the medulla discharge nervous energy in response to stimuli applied to various sensitive portions of the body during surgical anæsthesia. If the trauma is sufficient, exhaustion of the entire brain is observed after the anæsthetic effects have worn off, that is, despite complete paralysis of voluntary motion and loss of consciousness, due to ether, the traumatic impulses reach the wide awake centres in the medulla and also in every other portion of the brain. If, however, the nerve tracts from the field of operation be blocked with cocaine, and the element of fear be excluded, despite the intensity or the duration of the trauma within the operative zone so blocked, no exhaustion follows after the effects of the anæsthetic have worn off and no degeneration is apparent in the brain cells. It is therefore manifestly clear that ether, by inhalation, is but an " anæsthetic veneer " which, while it produces unconsciousness, apparently protects none of the brain cells against the trauma of a surgical operation.

This proposition, it is claimed, explains why, in the employment of the usual methods of inhalation anæsthesia, a robust patient may go to an operating room for an operation of an hour's duration, to emerge beaten, broken and shattered, and in such condition that months, or even years, may intervene before he recovers his normal status of health. The operation of these injurious impulses during surgical procedure Crile calls " noci-association," and that state which he obtains by employing certain methods of nerve blocking to pre-

vent these traumatic impressions from reaching the cerebrum, he calls "anoci-association."

From the foregoing, it is evident that progress in anæsthesia, whether it concerns method or agent employed, must incorporate in its possibilities all of the factors concerned in the production of anoci-association. We are strongly of the opinion that no method, however much it has to commend it, will not meet the new standard set by Crile unless by its employment the patient is anæsthetized quickly and pleasantly, that is without the sensation of suffocation or strangling and with the absence of a stage of excitement. The patient should pass into a narcosis closely simulating normal sleep, should be completely relaxed so far as the muscular system is concerned and, during a long and even trying operation, the pulse and respiratory wave should be subject to very little variation; the patient should awaken promptly after the operation, there should be no nausea or vomiting, comparatively little or no post-operative pain, no unpleasant after-effects of any kind that leave disagreeable memories on the mind of the patient. These are the advantages claimed by Crile when he employs gas and oxygen anæsthesia with nerve blocking from the operative field with urea and quinine hydrochloride. These conditions may be duplicated with intravenous anæsthesia with even some additional advantages. In the preliminary reports of our experiences we were careful to explain that this method would have, in all probability, a comparatively restricted though definite field of usefulness, but its continual employment, not only in private practice but in a hospital where the anæsthetic risks are probably greater than anywhere in this country, has surpassed any form of anæsthesia ever employed in the institution.

Like many discarded or forgotten surgical procedures which, when revived, interest the medical profession by the charm of apparent novelty, general anæsthesia by the intravenous route was demonstrated as a possibility by Orè, in 1872, who used chloral hydrate as the hypnotic agent and whose report (published that year) covering every detail of his experi-

ences, is of extreme interest. He had considerable success in 51 cases but after a few fatalities, due perhaps both to the method and the drug employed, he discontinued its use. In 1909, Burckhardt, after extensive animal experiments, became enthusiastic over the intravenous method and attempted its use on the human subject, using chloroform at first but soon discarding it for ether, which he found quite as efficient, and much safer. At the Berlin Surgical Congress in 1910, six surgeons of prominence corroborated the success of Burckhardt, Kummel reporting 90 cases in his own experience, believing that it was particularly useful in aged and cachectic individuals.

Later, Fedoroff of St. Petersburg collected 530 cases from 3 Russian clinics, in which hedonal had been used in the same way and, although the cases embraced all kinds of surgical operation, there were no deaths attributable to the anæsthetic. Eight cases of temporary respiratory arrest, however, yielded to simple methods of artificial respiration. Up to this time, the method of induction of anæsthesia in this manner was somewhat crude, as Kummel pointed out, not free from danger, particularly of thrombosis. Burckhardt employed a simple infusion apparatus from which a mixture of a 5 to 7.5 per cent. of ether in normal saline solution was allowed to flow through a cannula into a convenient vein, usually the median basilic, until a sufficient narcosis was established to proceed with the operation. The flow was stopped by compression of the rubber tube, connected with the cannula, until the patient began to show signs of returning consciousness, when the solution was again admitted to the circulation, and so on until the operation was completed. Fedoroff and his colleagues used a 0.75 per cent. of hedonal in normal saline solution, in much the same way except that the cannula was entirely withdrawn from the vein to be reintroduced into a fresh one when more anæsthesia was required. Kummel sought to obviate the danger of thrombosis by providing two tanks, one with normal saline and the other containing the anæsthetic solution, both being connected with appropriate control stop-cocks and a Y-connection so that,

even though the anæsthetic solution was cut off, the normal saline flow could be continued, and thus the circulation in the vein at no time be absolutely stopped. This method did not give a smooth, even anæsthesia and finally Rood devised a most ingenious apparatus, safe, simple, and efficient, which has answered all the requirements for maintaining a continuous, easily regulated flow, which may be kept at a uniform temperature, and places the degree of narcosis quite within the easy control of the anæsthetist.

We have constructed such an apparatus, largely from materials at hand, with a justifiable spoliation of some of our other equipment, which has embodied all of the essential features of Rood's valuable suggestions, so that the use of this method of anæsthesia does not necessitate a very expensive outlay (see Fig. 1).[1]

It should be understood at the outset that this procedure is not urged to supplant any of the well recognized forms of anæsthesia in general use, nor do we entertain the hope or belief it will become the method in universal use. We are convinced, however, that, with further experience and development, its efficacy and safety will assign it a definite field of usefulness. In the generally employed method of respiratory anæsthesia, some volatile agent is introduced into the circulation by way of the lungs, the rate of introduction being affected by certain variable factors, the energy and depth of the respiratory effort, laryngeal and respiratory spasm, the condition of the bronchial mucous membrane, and the skill of the anæsthetist. There are, of course, many other conditions which modify the amount of anæsthetic required to produce surgical narcosis in a given subject, but those mentioned are present as variable factors in every case where the indirect or respiratory method is employed. It is manifestly clear that, under these conditions, in every case of anæsthesia produced in this way, more of the anæsthetic is introduced into the body than is necessary, the excess is stored up in the tissues to be gradually

[1] The Kny-Scheerer Co., of New York, has made a very satisfactory apparatus, after our designs, for intravenous infusion anæsthesia.

eliminated, a matter of several days duration, with often the unpleasant, if not serious consequences, which mark the toxic effects of the drug employed. The delayed effects of anæsthetics, after narcosis and after the patient has recovered from the shock, and other more or less immediate results of the operative procedures are worthy of closer and more extended study. It is reasonably certain, in the minds of most observers, that acute yellow atrophy of the liver (or a poisoning of the hepatic cells and interference with their metabolic activity), injuries to the myocardium, and the developments of a state of acidosis allied to diabetic coma, are occasional late sequences of chloroform administration. The well-known irritating effects of ether upon the respiratory apparatus and the kidneys are well understood. The evil effects of any anæsthetic do not depend upon the amount taken into the lungs but the amount absorbed from them by the blood, and again the amount absorbed by the tissues from the blood, and especially those tissues of the nervous system which are intimately associated with vital functions.

It must be borne in mind, as pointed out by Buxton, that, if the administration of an anæsthetic is kept at the same level, narcosis will deepen, and if the anæsthetic is a stimulant, such as ether, the initial stimulation of the nervous system gives rise to an ever-increasing exhaustion. If the anæsthetic is a depressant, such as chloroform, its maintenance at the same level of strength will turn depression of function into profound exhaustion. However slight may be the degree of respiratory failure, it leads to diminished pulmonary ventilation, and this to lessened oxidation which, with failing blood-pressure, causes the tissues of the body to be enfeebled to the point of being rendered moribund.

The correct interpretation of the situation is the recognition of the anæsthetist of the fact that, when once a level of narcosis sufficient for the purposes of the surgeon is reached, very little anæsthetic is necessary to maintain that equilibrium once it is established, and that, so long as the tissues are not over-narcotized, the cells will part with the anæsthetic and regain

their normal physiological status when the administration of the drug is withdrawn.

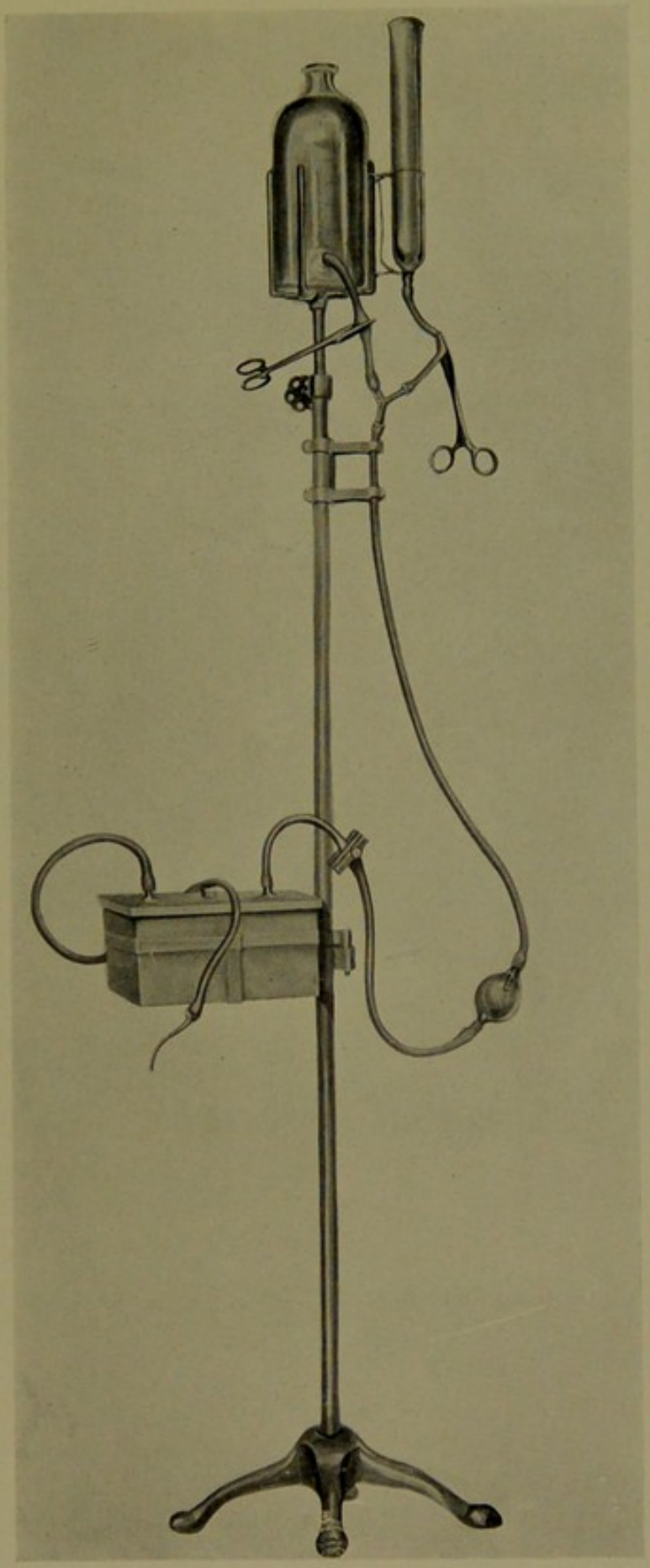
In the employment of intravenous anæsthesia, the agent is directly introduced into the blood, a minimum amount is used, it is maintained there at a certain definite percentage, and its employment can be withdrawn abruptly without storing up in the body reservoirs such excess as may subsequently prove harmful to the patient. In this method the production of anæsthesia is very rapid, the preliminary state of excitement is nearly always absent, the patient breathes almost naturally, the color of the skin remains good, and the relaxation and flexibility of muscles are absolutely satisfactory to the operator. The degree of narcosis can be maintained to a nicety and at the completion of the operation the patient often answers questions rationally before leaving the operating room, and returns to bed with better physical signs than before the anæsthetic was administered.

For the safe and satisfactory induction of anæsthesia by the intravenous route it is highly essential that the details of the technic, which is remarkably simple, be carefully and systematically observed. It is very remarkable that trained anæsthetists have failed utterly with this method in the first attempts because they neglected to familiarize themselves with a few important principles which are absolutely necessary if this method is to be successfully employed. Failures to obtain a satisfactory degree of narcosis, unfortunate complications and even fatalities have occurred which, in our judgment, are utterly unwarranted. In a very active surgical service at the Metropolitan Hospital, Department of Public Charities, Blackwell's Island, the *bete noir* of the surgeon has always been the anæsthesia. The patients for the most part are from the poorest quarters of the city, reduced by privation, hard work, poor hygienic conditions, alcoholism and pre-existing disease. They are frequently extra hazardous risks viewed from either an anæsthetic or surgical stand-point; but such has been our experience with intravenous anæsthesia that, in that institution, it is the safest, most efficient, freer from post-operative com-

plications than any form of narcosis ever employed in the history of the Hospital. Our work has embraced about all of the operations usually performed in a large general surgical service, males, females and children and, at the present time, we can recall only one death in about 350 administrations that could be justly attributed to the method of anæsthesia and in that single instance the regrettable fatality was due to the unfortunate misunderstanding of a verbal order as to anodynes after the operation. Our first experience was with the simple infusion apparatus as recommended by Burckhardt, the originator of the method, but subsequently we used the more elaborate and satisfactory technic of Rood.

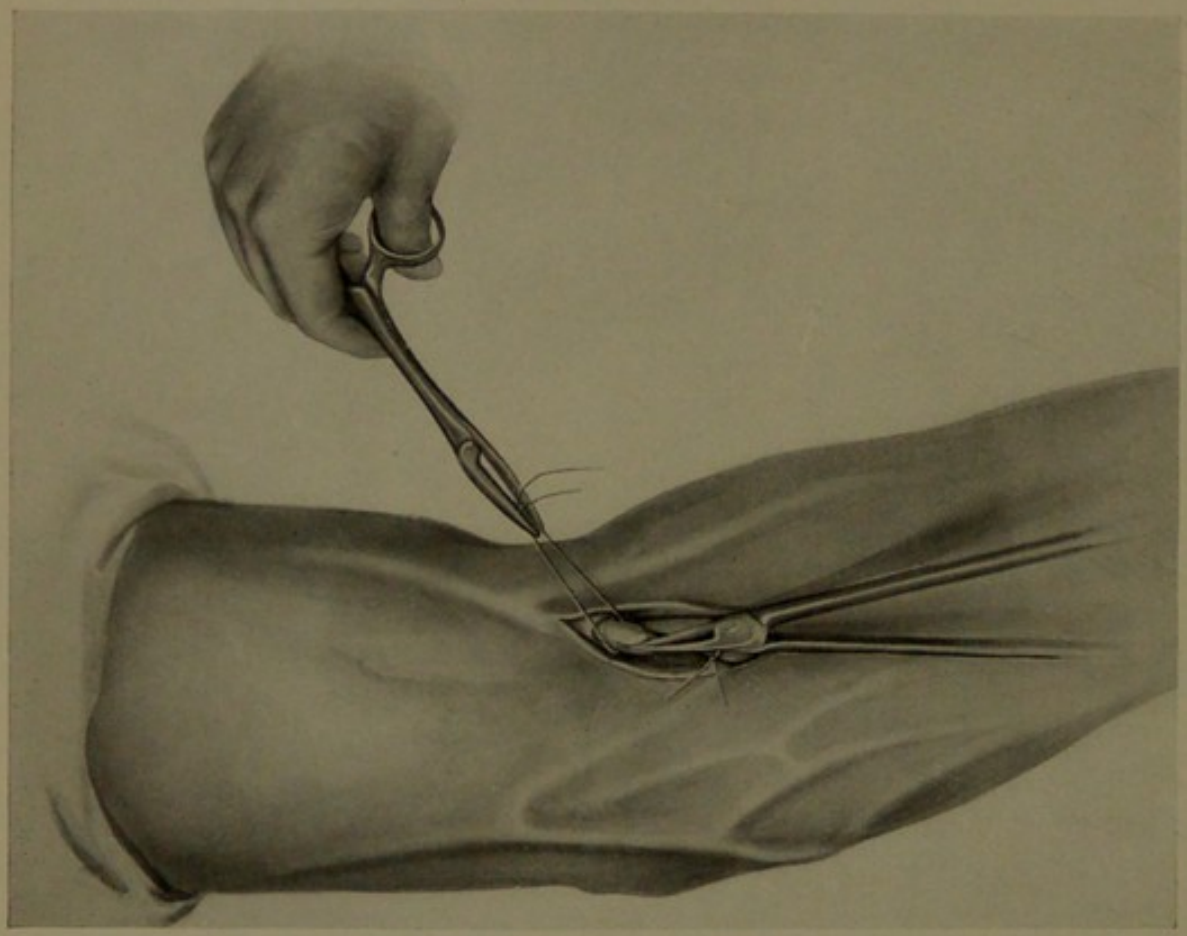
For the intravenous use of ether, the patient, having been prepared for operation, is taken to the anæsthetizing room about thirty minutes before the time for operation and placed preferably upon the operating table which is to be used during the operation. A subcutaneous injection of morphine sulphate, gr. 1/6, atropine sulphate, gr. 1/100 and scopolamine, gr. 1/100, is given at one dose, preferably in the loose tissues of the chest, abdomen or thigh. From this time until the actual anæsthesia is accomplished, it is extremely advisable to keep the patient as quiet as possible so that, when the administration begins, the patient is in a condition of reposeful relaxation of mind and body. No matter how anxious or fearful of the result of the operation, the patient in thirty minutes is sustained and supported by the hypodermic medication and the injurious effects of acute fear, which Crile has demonstrated are identical with those of acute shock, are successfully combatted. A five to seven and one-half solution of ether with filtered sterile Ringer's solution (normal saline solution may be used if the other is not available), at a temperature of 85° F. is poured into a reservoir which has a capacity of 2000 c.c. The solution is thoroughly mixed and care should be taken to see that the ether is thoroughly dissolved, for even after violent succussion there may be some stratification, the lighter ether floating upon the surface of the solution. At that temperature ether is soluble in about 10 parts of normal saline solution. It is

FIG. 1.



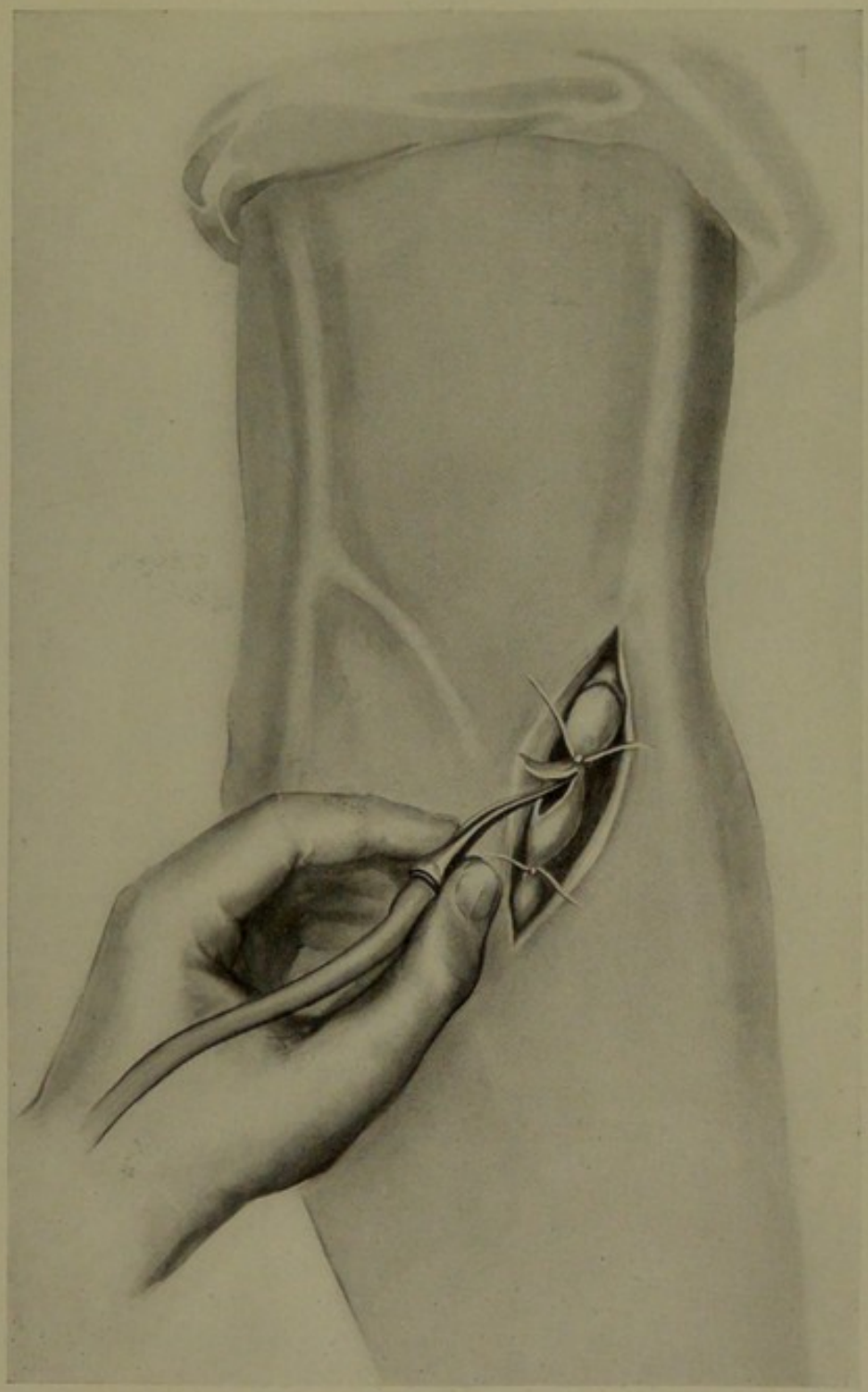
An apparatus designed for use in any form of intravenous anæsthesia. The narrow tube by the side of the reservoir is for the introduction of a solution of hedonal or isopral preliminary to the employment of a solution of ether.

FIG. 2.



Vein has been exposed and ligated distally, this ligature not shown in illustration. Vein is being opened with scissors.

FIG. 3.

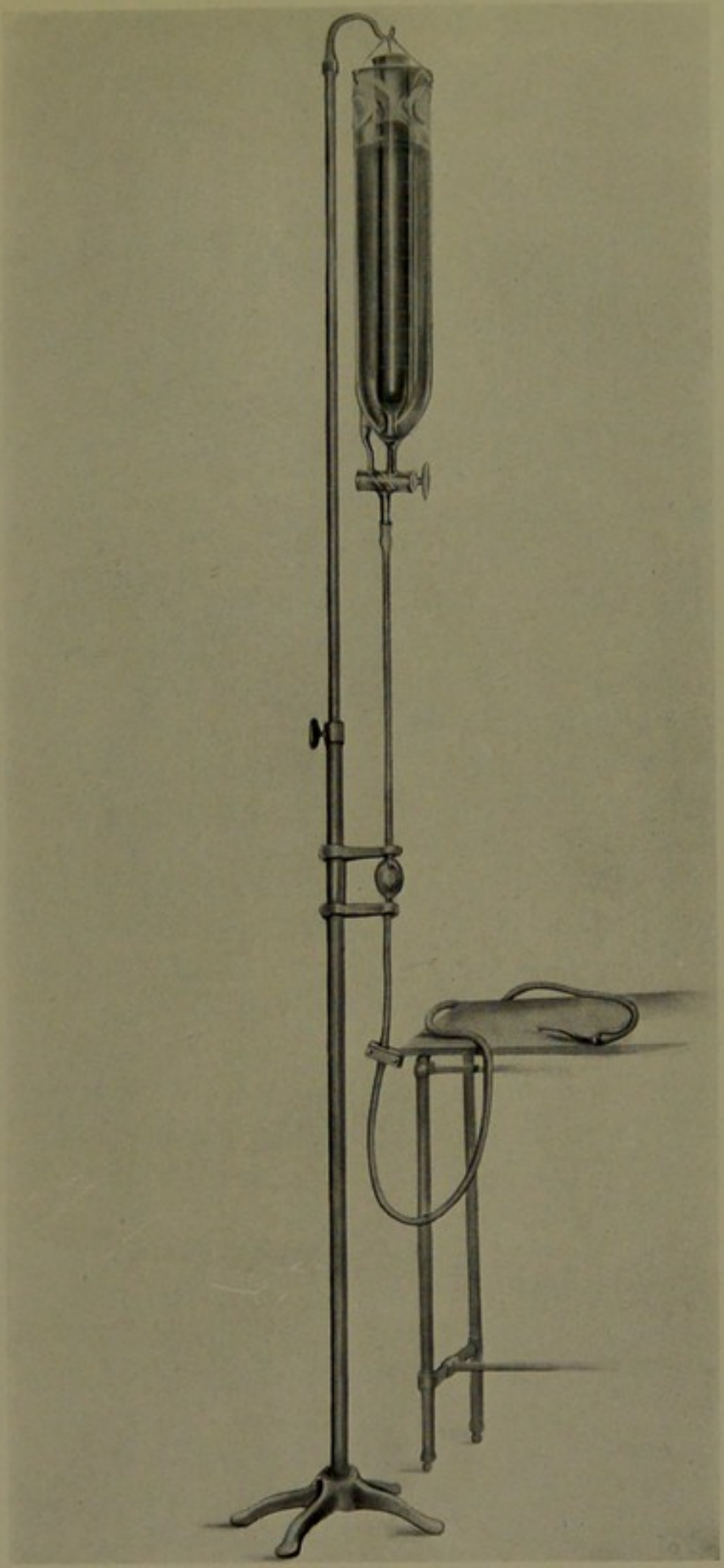


Cannula introduced and tied in the vein.

FIG. 4.

Patient under anæsthesia by intravenous method. Note globular indicator with control stopcock. Also method of maintaining arm in proper position.

FIG. 5.



Another model apparatus for intravenous anæsthesia in which the reservoir and tube for preliminary narcosis is in one piece, and the solutions controlled by an ingeniously perforated glass stopcock.

important to note that the introduction of a large amount of solution at a temperature so much lower than that of the body produces no harmful effects, either immediate or remote. It is noteworthy to add that ether boils at 96° F. and even before that point is reached, it will have vaporized and escaped, thus offering an explanation of the failure to produce anæsthesia when ether was added to a normal saline solution, the temperature of which was at or near 96° F. with a mistaken idea that it would better conserve the vital forces of the patient.

The solution having been prepared, the reservoir is adjusted on a stand eight feet above the floor level, at which point it remains during the administration. The fluid flows through an indicator (which contains a pipette) then through a rubber tubing into a blunt cannula and so into the vein. The indicator consists of a cylindrical or globular bulb of a capacity of from two to four ounces with an inside pipette very similar to that used in the Murphy apparatus for protoclysis. When the apparatus is working properly, the lower half of the indicator is filled with solution while the upper half contains air. The solution flows from the tank through the pipette and drops on the surface of the fluid in the lower half of the indicator. By means of a compression top, placed below the indicator, the rate of flow can be accurately controlled and, if the fluid in the bulb is kept at a proper level, a satisfactory index is furnished as to the rate the solution enters the vein (Fig. 1). Usually the arm furthest from the operator is selected and the median basilic or cephalic vein exposed, but should the operative field be the skull, face, neck, or chest, where the infusion apparatus would inconvenience the surgeon or his assistant, the internal saphenous at the internal malleolus is selected. As a matter of fact, any vein, in any locality remote from the operator, may be utilized, the simple precaution being that it is superficial, free from varicosities, and sufficiently large to be readily exposed and to admit the small cannula through which the anæsthetic solution is to be introduced into the system. If the elbow is selected, a padded splint, large at one end and tapering to a size somewhat wider than the forearm is placed beneath the

patient, extending from beyond the tips of the fingers to the opposite side of the body; a few turns of a three-inch bandage just above the wrist will maintain extension of the forearm and prevent involuntary movements which might occur in the first stage of anæsthesia and dislodge the cannula from the vein, an embarrassing but easily preventable accident. A space of about four to six inches over the bend of the elbow is now firmly wiped once over with a 5 per cent. solution of thymol in carbon tetrachloride, on a piece of gauze. This is sufficient to thoroughly sterilize the skin, which has not received any previous preparation. It has an advantage over iodine, usually employed, in that it is more efficacious and, as an antiseptic, does not discolor the skin, the latter a great advantage when superficial veins are to be dissected. It is not advisable to bandage the distal extremity of a limb to render the veins more prominent as the compressor must be very quickly removed when the cannula is introduced and that often adds to the difficulty. If the veins are not particularly prominent, an assistant may make some pressure with the hand on the upper and inner aspect of the arm while the vein is being exposed. There should be no blundering at this point, since nothing so disturbs the *morale* of the patient, destroys confidence and adds fear and anxiety, when composure should be supreme, as the futile, clumsy attempts to find the vein by anæsthetists not accustomed to doing surgical work.

We make it very emphatic that the exposure of the vein and the introduction of the cannula should be done by the operating surgeon, the anæsthetist taking charge of the apparatus and watching the respiration and cardiac action. It is important that this small but important step be done with scrupulous regard to asepsis, since septic thrombosis at this point might lead to unpleasant after results. The anæsthetist therefore relieves himself of a burden of considerable responsibility when he relegates the surgical part of this procedure to the experienced operator. The skin over the vein selected is infiltrated with a few drops of one-half of one per cent. solution of cocaine, sufficient to make a bleb one-half inch in

diameter. The skin containing the bleb is drawn aside from the vein with the thumb of the left hand so as not to be directly over the vein, and a small incision one-third to one-half an inch made through into subcutaneous fat. The vein is now exposed by wiping with a bit of gauze for two or three firm strokes. A small hæmostat, with a double ligature of No. 1 catgut, is now carefully thrust beneath the vein and, by gently moving it horizontally in and out, the vessel is lifted from its bed and the exposure is complete. The ligature is cut, the lower half is tied tightly and attached to a hæmostat, the upper half being tied loosely with half a knot and also clamped with a hæmostat. The operator now takes the proximal ligature in his left hand, the assistant making slight tension on the one distal; the vein is lifted and put somewhat on the stretch. With a small rather blunt scissors an incision is made embracing about two-thirds the calibre of the vessel (Fig. 2). The operator now takes the cannula in his right hand and, slightly relaxing tension on the proximal ligature which he holds, he is able usually to quickly insinuate it into the cavity of the vein. By manipulating the proximal ligature as to tension, he is able to facilitate this movement, though it is often advisable to have the assistant pick up the flap of the incised vein with a small pair of anatomical forceps which exposes the lumen, steadies the vessel and very considerably facilitates the introduction of the cannula. The half loose knot in the proximal ligature is now drawn snugly down on the cannula, which is sufficient to hold it in place (Fig. 3). A piece of adhesive plaster about 3 inches wide is placed about the rubber tubing connected with the cannula, which relieves all tension and tends more than anything else to prevent the accidental slipping of the tube from the vein. A large gauze pack is now placed over the incision and the surgeon and assistant take their respective places to begin the contemplated operation (Fig. 4). We have found that actual exposure of the vein and tying on of the cannula is the most satisfactory and safe procedure, many suggestions having been made as to the use of a technic similar to that employed in the salvarsan treatment, special needles have been

made and tried only to return to the very satisfactory procedure described above.

The solution should be administered at a full flow at the beginning, the anæsthetist reducing the stream at the appearance of the usual signs of surgical anæsthesia. It is quite as incumbent upon the anæsthetist to take the usual precautions to secure and maintain an unobstructed air-way and efficient respiratory act, as in the usual method of anæsthesia. Ether is rapidly eliminated by the lungs in this method, and, as is true of all methods, efficient respiration prevents accumulation and tension on the tissues, increases its output, and lessens its toxicity. In from one to five minutes anæsthesia will be complete and the operation may proceed.

It is highly important, as was noted above, to be economical in the use of the anæsthetic solution; the patient should be placed in the appropriate position for the intended operation, the operative field draped, the skin disinfection completed, and the surgeon absolutely ready to make the initial incision when the cannula is inserted into the vein. There is a limit to the patient's tolerance for even salt solution, and it is very desirable that any portion of the period of anæsthesia be not wasted upon preparation but reserved solely for the actual operative technic. When the degree of narcosis is obtained, which varies somewhat with the nature of the operation, the flow into the vein is reduced by the control-cock just below the indicator. It may be allowed to drip in a very fine stream or at the rate of 40 to 60 drops per minute, the corneal reflex affording a reliable guide for administration. The anæsthetist readily becomes acquainted with the effects of the drug by this method, and as narcosis can be absolutely and beautifully controlled, there is no need for any embarrassment to the operator from involuntary muscular contractions. Again let it be urged that careful attention be directed to the maintenance of an open air-way, and as the muscles of the jaws and neck are very much relaxed, the tongue should not be allowed to drop back into the pharynx. It is more important to attend to these respiration precautions than if the patient were being

anæsthetized by the inhalation method. Latterly we have found the use of the Hewitt breathing tube very useful in assisting to maintain proper air-way and also as an aid to holding the tongue forward. Our usual practice is to fix the tongue with a pair of fine tenaculum forceps and let them hang by their own weight. We advocate a continuous flow in intravenous anæsthesia, no matter what agent is employed as the hypnotic, though a few times we have interrupted the stream for a few moments without any appreciable harmful effect at the conclusion of the operation unless it has been quite prolonged; particularly if ether alone has been used, the dressings should be applied before the flow is actually stopped, as the return to consciousness often comes very promptly and the patient may resist efforts to finish the toilet of the incision properly. The blood-pressure rises slightly with the use of ether in this way—we use it preferably in the old and cachectic patients, avoiding its use in young, full-blooded, or alcoholic subjects.

Oozing is more noticeable, perhaps, in the operative field, and, if the cavity of the abdomen is the seat of the operation, fluid rapidly accumulates there. If extensive adhesions are to be dealt with, the fluid rapidly becomes blood-stained, and there might be instances where this might embarrass and delay the operator, but we have not been so troubled. The patient may be brought from one degree of anæsthesia to another very rapidly by the judicious use of the control indicator, and it is well that the operation be entirely finished and dressings applied before the administration is stopped, as the patient returns to consciousness very quickly. If the administration has been skilfully performed, the patient will quietly drop to sleep without any appreciable indication of a stage of excitement. The face will flush, eyes roll and some of the voluntary muscles stiffen for perhaps a few seconds, when suddenly the patient seems to have fallen into a quiet but deep sleep without the noisy stertorous respiration usually associated with narcosis. The usual signs, corneal reflex, pupillary indication, etc., are about as noted in the same degree of anæsthesia

by the inhalation method. At the conclusion of the operation, which may last from two to three hours, at the expenditure of about 1000 c.c. of solution per hour, the cannula is withdrawn by a quick jerk from the vein, the loose half knot of catgut is tied which ligates the proximal portion of the vein. The wound is closed with a few fine silk sutures of 000 silk on No. 10 straight needles, wiped once with carbon tetrachloride and thymol, 50 per cent. solution and an aseptic dressing applied. The patient is returned to bed and, if much solution has been used and the operation prolonged, a semi-Fowler position is employed and the nurse instructed to turn the patient every one or two hours. This is a necessary precaution for, if a very great quantity of fluid is used, there are naturally some possibilities of pulmonary œdema and, curiously enough, certain spots on the back and buttocks often develop, looking like bruises. This is due to the anæsthetic fluid settling in the loose fatty tissue of the most dependent portion of the body. Occasionally the patient will have a chill such as occurs when saline infusion is given to combat shock. This condition quickly subsides, particularly if hot water bags are placed about patient. It is a curious fact that this phenomenon will occur when solutions ten degrees higher than the bodily temperature are introduced into the circulation. The employment of ether in this way seems almost devoid of danger from either immediate or remote complications and represents the basic type of intravenous anæsthesia, from which have grown many modifications.

We have experimented with a considerable number of drugs, either alone or in combination in the same solution with ether. The combination of drugs having distinct hypnotic properties, in the same solution with ether, seems to produce a very smooth, even and satisfactory narcosis, which could be maintained with a smaller amount of fluid than when ether alone was used. Paraldehyde and ether gave splendid results, deep anæsthesia being produced almost as quickly as with hedonal, but we have practically discontinued its use for the reason that, as it is very rapidly eliminated from the lungs, the

vapor seems to produce a decided irritation of the larynx on certain individuals, particularly to those addicted to alcohol, and a crowing, croupy, spasmodic respiration due to spasm often supervenes at about the close of a moderately long operation. This condition would not banish it from our armamentarium were it not for the fact that the employment of mixtures containing paraldehyde were the ones that produced blood changes worthy of note. Hedonal 0.75 per cent. and ether 5 per cent. makes an admirable combination but such satisfactory results, with a different drug and slightly altered technic, were obtained, that it may be said to be the last word on the subject. Attached to the side of the reservoir usually employed, there is a secondary salvarsan tube of about 350 c.c. capacity. Rubber tubing from the two glass receptacles are attached to the divergent arms of a glass Y and the tube, which is connected with the indicator and cannula, is attached to the remaining free arm. A hæmostat is clamped upon the tubes leading from both vessels. Into the smaller is poured 250 c.c. of a one and one-half per cent. of isopral in Ringer's solution, and into the other 2000 c.c. of a 5 per cent. solution of ether. The vein being exposed and opened, the hæmostat is removed from the tubing leading from the smaller vessel containing the isopral solution, the cannula is inserted into the vein and fluid is allowed to flow very slowly so that it will take between four or five minutes for that quantity to enter the circulation, according to the tolerance of the patient; complete anæsthesia is induced with a greater or less amount of the solution but almost invariably it is accomplished with the entire amount, the condition and resistance of the patient notwithstanding. Before the entire quantity has entered the vein, the hæmostat again is clamped on the branch tubing and that from the one leading from ether solution simultaneously removed, so that complete anæsthesia being induced, it is continued with ether. This same technic can be applied to hedonal in the same way, only using a 0.75 per cent. solution. Intravenous anæsthesia induced in this way is very satisfactory, safe and reliable; the drugs used in the way described seem to have almost a synergis-

tic physiological action in producing narcosis. The important part of the procedure is to give hypnotic solution very slowly until anæsthesia is induced, immediately this is accomplished, stop its administration and advance the ether mixture. The narcosis is probably better and certainly more safely produced in this manner, and may be continued and maintained with the expenditure of less fluid than by any of the other methods referred to and it may be said that, at the present state of development, it is easily the method of choice.

*Blood Changes.*—In every case it was found that ether raised the blood-pressure from 2 to 24 mm., this rise being followed by a fall of 2 to 20 mm. in from one to three hours and then gradually returned approximately to the point observed before operation.

Hedonal invariably lowered the blood-pressure from 6 to 25 mm. of mercury, paraldehyde in about the same proportion, so also isopral. When mixtures were used, such as hedonal and ether, paraldehyde, or isopral and ether, the blood-pressure was influenced to the extent of being about the same as before the operation, as only a small quantity of the hypnotics was used in the anæsthetic mixtures. They, however, in every instance prevented the increased pressure noted when ether-scopolamine-morphine combination was used. It was singularly noted that female patients showed little or no change in the blood pictures, neither did males in operations of short duration. Alcoholic habitues naturally required more anæsthetic and, in one case, in which anæsthesia was accomplished with a 5 per cent. solution of paraldehyde in normal saline, there was decided crenation of red cells with some clumping crenation, and some crenation was noted when a mixture of ether 3 per cent. and paraldehyde 2½ per cent. was employed. Some crenation was also noticed in one case where a large quantity (3500 c.c.) of 7 per cent. ether in normal saline was used. In every case the blood picture returned to normal in about four hours.

Hæmoglobin, estimated by Tallquist scale, showed an average diminution of 5 per cent. There seemed to be no changes

either in appearance or number of the leucocytes, and where an actual leucocytosis was observed before the infusion was given, the blood picture was practically unchanged. The erythrocytes were not materially affected except in three cases in which narcosis had been produced by paraldehyde.

*Urinary Examination.*—The urinary analysis made before the operation and for three or four days afterward showed no marked differences in the specimens. The total amount was increased and specific gravity lowered during the first twenty-four hours; often the specific gravity and solid content of the urine remained unchanged. In no case, even after employing 7½ per cent. ether solution, did blood, albumen or casts appear in the urine, though German observers did report occasional cases of transient hæmoglobinuria after the use of the stronger ether mixtures. It was quite surprising that there was not a large urinary output after the infusion of large quantities of fluid, so much so that the patients were regularly catheterized, thinking perhaps there might be some vesical paresis from over-distention, but we failed to find at any time a urinary output in proportion to the amount of fluid introduced into the circulation.