THE MEDICO-CHIRURGICAL SERIES

No. 1.

THE PRACTICE OF ANÆSTHETICS

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GENERAL SURGICAL TECHNIQUE

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EDITOR'S PREFACE

THE name given to this series—"Medico-Chirurgical"—is no mere academic title: it is intended to convey the fact that in these volumes surgery and medicine are dealt with conjointly. We are so accustomed to text-books treating medical and surgical subjects separately, that it is something of a revolution in medical literature to bring out works dealing with diseases considered in both their medical and their surgical aspects conjointly. Not only has the divorce of medicine from surgery, as regards text-book writing, become complete, but we actually have books on surgery in which the science and the art are held to be so distinct that the art is separated from the science and separate volumes are devoted to each.

Disease, its nature and treatment, appears, in our text-books, to be specialized to an extent that is neither practical nor scientific. When studying a disease, and considering its course and treatment, we have to consult two, three or more volumes, by different authors; we are apt to lose sight of the disease as a whole, and to consider its varying and various phases and stages as distinct entities. In the books of the "Medico-Chirurgical" series the reader will find the medical and surgical aspects of a disease, as well as the medical and surgical treatment, considered as a whole, instead of in piecemeal fragments in separate volumes. Where necessary, a physician and a surgeon co-operate in writing a volume, and together present the medical and the surgical aspects of a disease in a completed picture.

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PRACTICE OF ANÆSTHETICS

CHAPTER I

INTRODUCTION AND BRIEF HISTORICAL NOTE.

THE chief agents used to bring about general anæsthesia in the present day are nitrous oxide gas, ethyl chloride, ether, chloroform, and various mixtures of these with each other and with other substances. Anyone who undertakes to anæsthetise a patient for a surgical operation, of whatever magnitude, must be familiar with the uses, modes of administration, relative advantages and dangers of all these drugs. An anæsthetist should never commence the administration of an anæsthetic without having an alternative one ready in case of need.

Until about 1840 the value of these drugs was unknown to surgery, though alcohol, cannabis indica, opium, mesmerism, &c., were all used to a limited extent. Compression of the carotid arteries had also been employed to dull the pain of operations, by depriving the brain of part of its blood supply. This latter means was re-discovered about two years ago, and written about, as though it were something new, under the title of " Javanese Anæsthesia."

Nitrous oxide gas was first employed for anæsthetic purposes by Horace Wells, a dentist of Boston, U.S.A., in 1844. It did not, however, come into general use until 1868, when Mr. Clover adopted this gas as a preliminary to the inhalation of ether.

The introduction of ether as a general anæsthetic for surgical purposes is usually ascribed to William Morton, also a dentist of Boston. He first tried its effects on himself, pouring the ether on his handkerchief; and then he used it successfully on a patient for tooth-extraction in 1846. Some writers, however, credit Dr. Crawford Long, of the United States, with the discovery of ether in 1842. At the end of the year 1846, Liston performed an amputation through the thigh at University College Hospital, London, upon a patient anæsthetised with ether by Mr. Squire. In the following year ether began to lose favour, owing to the introduction, by Sir James Simpson, of Edinburgh, of chloroform; which for some time was considered to be a safe anæsthetic, but the fallacy of this teaching soon became obvious. Since then, few permanent additions have been made to the list of general anæsthetics, except ethyl chloride, and various mixtures of the afore-mentioned substances with each other and with other chemical bodies; amongst the chief of which may be mentioned the A.C.E. mixture, the C.E. mixture, and the combination of nitrous oxide gas with oxygen. In the present volume no attempt will be made to treat of every known anæsthetic, but only those that are in general use at the present time.

To turn to the practical side of the question, the duties of an anæsthetist are :—

(1) To give suitable directions as to the preparation of the patient.

(2) To make a careful selection of the best drug to employ, and the best mode of administering it, in each individual case.

(3) To give his sole and undivided attention to the safe and satisfactory anæsthetisation of his patient, and to treat any emergencies that may arise in spite of his care.

(4) To see the patient safely back to bed in a good position, and to order such after-treatment as he may deem advisable.

The Medical Acts make no mention whatever of the subject of anæsthetics, and it is a disputed point as to who is responsible in law for any injury caused to a patient by an anæsthetic. Dr. Waldo, one of the coroners for London, has stated that the surgeon is solely responsible, not only for the operation, but also for the anæsthetic. This, however, can only be taken as his private opinion, for the case has never been determined in a court of law. If such an opinion were upheld, it would be obviously grossly unfair both to the surgeon and to the patient ; for the surgeon cannot possibly be expert in such matters, and the patient would suffer from the surgeon being unable to devote his entire attention to the operation that he is performing. Moreover, it may well be asked, if the surgeon be solely responsible, why is it that coroners practically always subpœna the anæsthetist, and not the surgeon, in a case of death occurring during an operation ?

It would nevertheless seem that the surgeon is responsible for choosing a fit person to administer the anæsthetic, and that he would be culpable if he allowed an unregistered person to perform this duty, unless he could show that it would have been impossible to obtain the services of a registered practitioner without delaying the operation so long as to be detrimental to the patient. Sometimes, instead of the surgeon choosing the anæsthetist, the latter is chosen by the patient; and occasionally the choice of surgeon is left in the hands of the anæsthetist. In such cases, it would be obviously absurd to hold the surgeon responsible for the anæsthetist.

By law, every registered practitioner is competent to administer anæsthetics, however incompetent he may be in actual practice. As a matter of fact, anæsthetists fall into two categories: in the one, they are experts at their own branch of medicine, and act on a par with the operator; and in the other they have no special knowledge of the subject, and act solely as the assistant of the operator. In the latter case the surgeon must indeed take all responsibility; and I believe they are always ready to do so when they operate in hospital, while a recently qualified house surgeon or house physician administers an anæsthetic to the best of his ability with a necessarily small experience.

In private practice, however, the case is not quite similar; for then the general practitioner frequently constitutes himself the anæsthetist without reference to the surgeon, and sometimes apparently without due regard to the seriousness of his task. If the practitioner be in the habit of administering anæsthetics frequently, there is absolutely no reason why he should not do so; but if, on the contrary, his experience is very limited, he should not attempt any but perfectly straightforward cases, and the surgeon would be jointly responsible with him if anything went wrong. This does not merely mean the death of the patient; it might include any accidents whatever, such as post-anæsthetic insanity, various forms of paralysis, injury to the jaws, teeth, tongue or eyes, or burns from the chloroform or hot-water bottles. There might also possibly be an action for bronchitis or pneumonia following an operation; or even for failure of the operation, owing to the narcosis not being sufficiently tranquil.

It has been decided in the Courts that registered dentists are competent to administer nitrous oxide gas though they possess no medical qualification in addition to their dental one; but nothing has been settled about their administering ether or chloroform.

Any registered practitioner administering an anæsthetic knowingly for an unqualified dentist or surgeon would be guilty of "covering"; an unregistered person, however, may do so, according to the decision given by Mr. Justice Bucknill at the Liverpool Assizes on February 22, 1902. Such a person, says this authority, may administer chloroform, and cannot be convicted if the patient dies, unless want of skill is proved. Though the two dentists in the case were neither qualified nor registered, they had administered chloroform 350 times; and this showed to the judge's satisfaction that they did possess the required skill, and he therefore ordered their acquittal.

Anyone administering an anæsthetic for an operation which he knows to be illegal would presumably render himself jointly liable with the operator; but it is no part of the anæsthetist's business to enquire into the reasons for every operation that he assists at.

In addition to his legal obligations to the patient, the anæsthetist must also do his best to make the operation a success by choosing a drug and a mode of administration which will be most convenient for the surgeon ; but he must never allow this second consideration to supersede his primary duty towards the patient, which is to steer the latter through his period of unconsciousness with safety, and to cause him the least possible amount of ill-effects afterwards. If the surgeon *insists* upon a method which the anæsthetist knows from experience will endanger the life of the patient, it becomes his duty to retire from the case, unless he be in a subordinate position ; under which circumstances the surgeon must take full responsibility. In the present day, however, surgeons almost always leave the matter entirely in the hands of the anæsthetist, after stating in a general way what their requirements may be in any special case. There is nevertheless one important exception to this : viz., the position in which the patient's arms are to be fixed. The safest position for avoiding paralysis is straight along the sides of the body, and this is where the anæsthetist should place them. If that position be inconvenient to the surgeon, the latter must take the responsibility of having it altered in accordance with his requirements ; and he must not blame the anæsthetist if the musculo-spiral nerve gets injured.

CHAPTER II.

THE CHEMICAL PROPERTIES AND IMPURITIES OF THE CHIEF ANÆSTHETIC AGENTS.

NITROUS OXIDE GAS (N_2O) is a colourless gas, with a peculiar sweet taste and smell, and a neutral reaction. It has no irritant properties if pure, and can be breathed without discomfort. The specific gravity is 1·527, and the boiling point about —90° C. Water at 0° C. dissolves rather more than half its own volume of nitrous oxide. Liquefaction takes place under a pressure of 30 atmospheres at 0° C., and it is in this liquefied form that nitrous oxide is supplied by the manufacturers in steel cylinders; 50 gallons of the liquefied gas weighing approximately 15 oz. At ordinary temperatures it will keep for any length of time without undergoing any chemical change.

If obtained from a reliable firm, it is usually quite pure; but it may sometimes contain other oxides of nitrogen, or chlorine; and it would then cause coughing if inhaled. It may also contain some oil from lubrication of the apparatus, which gives the gas a nauseous and irritating odour.

Nitrous oxide is manufactured by heating nitrate of ammonium to 450° F., and washing the gas that comes off. The change that takes place is indicated by the equation :—

$$NH_4NO_3 = N_2O + 2H_2O.$$

The gas is not inflammable, but supports combustion.

ETHER, ethylic ether, or ethyl oxide, is a colourless, mobile, very volatile and inflammable liquid, having a chemical formula of $(C_2H_5)_2O$. It is neutral to litmus, and has a pungent odour and burning taste. The specific gravity is ·720, and the boiling point 96° F. The vapour is about two and a half times heavier than air ; hence, during administration, the inhaler should be held in such a position that the vapour may pour downwards towards the patient's face. Ether is only slightly soluble in water, but mixes readily with alcohol and chloroform. It is made by distilling rectified spirit, added in a continuous stream, with sulphuric acid ; that is, by the de-hydration of the rectified spirit, thus : $2C_2H_6O - H_2O = (C_2H_5)_2O$. The actual chemical change is represented by the equations :—

$$C_2H_6O + H_2SO_4 = C_2H_6SO_4 \text{ (sulpho-vinic acid)} + H_2O.$$
$$C_2H_6SO_4 + C_2H_6O = (C_2H_5)_2O + H_2SO_4.$$

It is then agitated with slaked lime and calcium chloride in water, and re-distilled to remove alcohol and water, and heavy oil of wine, which is also formed.

If ether be exposed to heat, light and air, the result will be the formation of acetic acid by oxidation ; but if it be kept in a cool dark place, ether will undergo no decomposition.

If acetic acid be present, a deep red colour will appear on adding an iron salt to the ether. If pure, no residue or offensive smell should remain on evaporation; and it should not distil at a lower temperature than 94 F°. If it does so, this would indicate the presence of methylic ether.

If any sulphuric or sulphurous acid remain from the manufacture, a precipitate will be obtained with barium chloride. It must be remembered that five different kinds of ether are in common use, some of which are quite unsuited for producing general anæsthesia, and may cause death if so employed.[1] The two best forms for inhalation purposes are:—

(1) Æther purus, B.P., sp. gr. 0·720; and

(2) Rectified ether, sp. gr. 0·720, which is made from methylated spirit, but contains no methylic ether if properly prepared.

The other ethers, viz., (3) æther, B.P., sp. gr. 0·735; (4) absolute ether methylated, sp. gr., 0·735; (5) methylated ether, sp. gr. 0·730, should not be used as general anæsthetics.

CHLOROFORM is a colourless, mobile and volatile liquid, having a pleasant sweet smell and burning taste. The specific gravity is 1·49, and its formula $CHCl_3$. It boils at 140° F. Its vapour is four times as heavy as air, and therefore the mask from which it is to be inhaled must always be held vertically above the patient's mouth. It is made by distilling rectified spirit with chlorinated lime and slaked lime; that is, by oxidizing and chlorinating the alcohol. Thus:—

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[1] A fatal result from the use of "local anæsthetic ether" was reported in the *Lancet*, August 7, 1875.

$$2C_2H_6O + O_2 = 2C_2H_4O(\text{aldehyde}) + 2H_2O.$$
$$C_2H_4O + 3Cl_2 = C_2HCl_3O(\text{chloral}) + 3HCl.$$
$$2C_2HCl_3O + Ca(HO)_2 = 2CHCl_3 + Ca2CHO_2.$$

It is then purified by washing with water and sulphuric acid, which latter chars and removes hydrocarbons without affecting the chloroform; it is next agitated with slaked lime to free it from acid, and with calcium chloride to free it from moisture. Finally, it is re-distilled, and 1 per cent. by weight of ethylic alcohol added; which renders the chloroform less liable to decomposition. It is of the utmost importance that chloroform used for anæsthetic purposes should be absolutely pure, and it must therefore be kept in a cool dark place, and in well-corked bottles, as light and air decompose it into chlorine and hydrochloric acid, which would cause great irritation if inhaled. The reaction to litmus must be neutral, there must be no irritation when it is inhaled, and no residue or unpleasant odour must remain after evaporation. A specific gravity below 1·49 would indicate adulteration with more alcohol than is necessary to prevent decomposition from taking place. No precipitate should appear when a solution of silver nitrate is added, and no colouration when shaken with sulphuric or chromic acid. When dropped into distilled water, there should be transparent globules with no milky appearance.

Chloroform made from rectified spirit is so expensive that most firms now manufacture it from methylated spirit or from acetone. All three forms answer to the tests of the British Pharmacopœia, and are indistinguishable from each other by ordinary chemical tests. Clinically, however, a difference is noticeable;

the rectified chloroform being the best for inhalation purposes, and the acetone chloroform being preferable to that made from methylated spirit. Dr. Wade,[1] the lecturer on chemistry at Guy's Hospital, has made numerous careful analyses of rectified and acetone chloroform by fractional distillation, with the result that he found that acetone chloroform was actually the purest form, while that made from rectified spirit contained 0·25 per cent. of ethyl chloride. By adding this small proportion of ethyl chloride to pure acetone chloroform, a drug is obtained which is identical in all respects with the best rectified chloroform.

ETHYL CHLORIDE,[2] C_2H_5Cl, is a colourless, mobile, and highly volatile liquid, having a specific gravity of 0·921 at 0° C., and boiling at 12·5° C., or 54·5° F. It has an agreeable smell, but is such a powerful anæsthetic that even one full breath of the vapour produces a peculiar dizzy and tingling sensation. The vapour is rather more than twice as heavy as air. It is prepared by the action of hydrochloric acid on ethyl alcohol, the chemical change being shown by the equation :—

$$C_2H_5OH + HCl = C_2H_5Cl + H_2O.$$

Ethyl chloride is only slightly soluble in water, but dissolves readily in alcohol. It is inflammable when brought into contact with a light and is decomposed, burning with a green-edged flame. It should therefore not be administered near an exposed light, or

[1] *Transactions of the Society of Anæsthetists*, vol. vii.

[2] For most of the following notes I am indebted to Messrs. Duncan Flockhart & Co.

when the cautery is to be used within the mouth. As regards the action of light and air, it is probable that ethyl chloride is in the same category as chloroform; that is to say, it can be kept unchanged if exposed to air or light singly, but the combined action affects its purity.

To detect **Impurities**, let a little of the ethyl chloride evaporate from the hand; no disagreeable smell should be perceptible. It must not redden litmus paper which is allowed to be in contact with it for at least fifteen minutes. The acid most generally present from faulty manufacture or insufficient purification is hydrochloric, but sometimes sulphurous acid is also present. Hydrochloric acid may be detected by shaking some ethyl chloride in a separator with half its volume of water. On separating the water and adding a few drops of silver nitrate solution, no precipitate or opalescence should be produced.

A lower specific gravity than 0·921 might be due to the presence of ether. The latter has not necessarily been added, but indicates carelessness in manufacture; it may easily be detected by its odour.

Detection of Foreign Organic Compounds Decomposable by Sulphuric Acid.—If ethyl chloride be shaken in a separator with one-fifth of its volume of pure, colourless, concentrated sulphuric acid, the acid on separation should be colourless; if it be yellow, it indicates the presence of empyreumatic bodies foreign to the ethyl chloride, which latter is unacted upon by sulphuric acid, unless after a very long standing. Acid thus coloured by impure ethyl chloride often evolves an unpleasant odour on addition of five times its volume of water.

I have obtained these somewhat full notes of the chemistry of ethyl chlorlde from Messrs. Duncan Flockhart & Co., because the drug was in use many years ago, but fell into disfavour owing to deaths occurring during its administration without obvious cause, which were probably due to a great extent to the drug being impure. Since 1900, an absolutely pure ethyl chloride has been made by this firm, at the suggestion of Dr. McCardie, of Birmingham, and this purity has caused it to become one of the most frequently used anæsthetics, whereas eight years ago it was only considered suitable for producing local anæsthesia. The absolute purity of ethyl chloride is probably quite as important as that of chloroform.

CHAPTER III.

THE PHYSIOLOGY OF ANÆSTHESIA.

THERE are numerous drugs which diminish or abolish pain, but which nevertheless are not included under the heading of General Anæsthetics. To obtain admission into this group they must fulfil certain conditions, the chief of which are :—

(1) To produce absolute insensibility of the patient to his surroundings and to pain, without causing any great discomfort during induction.

(2) To produce loss of all voluntary and most reflex movements.

(3) To be capable of being readily introduced into the system, and rapidly eliminated after the completion of the operation without injury to the patient.

(4) To act in a regular and constant way, so that its effects can be watched and controlled by the administrator.

General anæsthetics act on germinating seeds and on plants, as well as on members of the animal kingdom, but we shall confine our remarks here to their employment on human beings.

The general effects are produced by the vapour or gas being absorbed by the blood, and circulated through the system until the necessary quantity has reached the brain, and these effects occur whether the absorption take place through the lungs, rectum, skin, or the gastro-intestinal tract. For instance, everyone must have witnessed the more or less complete anæsthesia produced by the absorption of alcohol or other drugs when swallowed, and Dr. Dudley Buxton has devised a means of introducing ether into the system during prolonged mouth operations, by absorption from the rectum. But the safest and most generally satisfactory channel for the introduction of anæsthetics is the respiratory system, the more so, because the blood, which is charged with the narcotic vapour in the pulmonary capillaries passes directly to the left heart, and thence to the nervous centres where its action is required. When the vapour has reached the lungs, its absorption depends upon the temperature and barometric pressure at the time prevailing, and on the solubility of the vapour in the blood.

Mr. Bellamy Gardner[1] has called attention to the effect of barometric pressure on anæsthesia. He made a number of experiments with nitrous oxide gas and oxygen, noting the barometric pressure and temperature in each case. The table which he drew up is highly interesting, and from it I have taken firstly, the cases that were done at the same temperature but varying barometric pressure, and secondly, the cases during which the barometer stood at the same height, but the temperature was different. With a temperature of 64° F. and a barometric pressure of 29·65 inches, he obtained an average anæsthesia of 41·5 seconds; whereas with the same temperature and a barometric pressure of 30·48 inches, the average duration of the resulting anæsthesia was 54 seconds.

[1] *Transactions of the Odontological Society*, February, 1904.

Again, at a constant temperature of 65° F. in each case, he found that with a barometric pressure of 30·00 inches, his average was 45 seconds, and with a barometric pressure of 30·45 inches, his average was 51·5 seconds. So in each case, we find that with a constant temperature, an increase of barometric pressure caused, or at least coincided with, a longer anæsthesia. Then again, with a constant barometer and varying temperature, he shows that the results are equally definite. For, with the barometer standing at 29·7 inches, he obtained 43·5 seconds anæsthesia at a temperature of 68° F., and 45 seconds anæsthesia at a temperature of 66° F. Likewise, when the barometer stood at 39 inches, he obtained 46 seconds anæsthesia at a temperature of 57° F., and 45 seconds at a temperature of 65° F. In other words, with a stationary barometer, the higher the temperature of the room the shorter will be the anæsthesia obtained. Of course, it is easy to argue that other factors may have played a part in producing these results; and no doubt they did assist, but the results are definite and constant, and are worthy of notice.

Mr. Gardner further points out that the places at higher altitudes where the barometer is lowest, are the places where chloroform is most popular; and this fact he ascribes to the delayed absorption of the vapour into, and the quicker elimination from, the blood at low barometric pressures, which increase the safety of the drug. This would indeed account in part for the popularity of chloroform at Hyderabad, and agrees with my own experience in South Africa; though I think the necessarily freer ventilation of the operating room in tropical countries has also a great influence on the results obtained.

The physiological effects of anæsthetics, which are of chief importance from the clinical point of view, may be divided into :—

(1) Those on the Respiratory System.

(2) Those on the Circulatory System.

(3) Those on the Nervous and Muscular Systems.

The various phenomena which are normally or occasionally met with during the course of an anæsthesia must now be considered in detail under these three headings.

EFFECTS ON THE RESPIRATORY SYSTEM.

It will at once be seen that, owing to the mode of administration, these will be both *Local* and *General*. The former include coughing, retching, and spasm of the laryngeal muscles, due mainly to the vapour being presented in too concentrated a form ; but Dastre[1] states that the laryngeal spasm is really a central effect produced reflexly through irritation of the nasal and laryngeal mucous membranes. Increased activity of the salivary glands, and of the mucous glands of the mouth and upper air passages likewise occurs, especially with ether. Hyperæmia or actual congestion of the mucous membrane of the lungs and bronchi also occurs to a varying extent, particularly with ether.

The *General* changes on the respiratory system include a primary and temporary stimulation of the respiratory centre, causing deeper and quicker breathing, followed by stertor and sometimes a degree

[1] "Les Anesthésiques, Physiologie et Applications Chirurgicales,' par A. Dastre, p. 70.

of asphyxia. This latter may be brought about by congestion of the air-passages or swellings around them, or by the excessive secretion of mucus; again, in the case of nitrous oxide gas when given without the addition of air or oxygen, it may arise from actual deprivation of the normal amount of oxygen in the atmosphere. Spasm of the jaw and chest muscles may occur in connection with general muscular spasm during the stage of excitement, which may be so marked as to entirely stop the breathing, and call for special treatment. If the administration of the anæsthetic be continued, this primary stimulation of the respiratory centre gives place to depression, the breathing becomes shallow, feeble, and irregular, and the inspirations become broken, so that two or three efforts may be made for each inspiration.

As a general rule, any expiratory sound is of the nature of phonation, and occurs only during light anæsthesia; whereas stertor occurs with inspiration, and usually denotes a more profound anæsthesia. In this connection it is necessary to distinguish between the different kinds of stertor, as our procedure must be regulated to some extent in accordance with the nature of the sound produced. Dr. Robert T. Bowles, in "Quain's Dictionary of Medicine," tabulates these as follows:—

(1) NASAL STERTOR, due to the approximation of the alæ nasi.

(2) BUCCAL STERTOR, which is produced by the flapping of the lips and cheeks, and occurs most frequently in edentulous subjects. It should be prevented by placing a dental prop, or other form of gag, between the jaws.

(3) PALATINE STERTOR, due to the vibration of the soft palate.

(4) PHARYNGEAL STERTOR, due to the tongue falling back, or being spasmodically drawn back, against the posterior pharyngeal wall; this may be remedied by pushing the lower jaw forward from behind the angle, but sometimes tongue-forceps are necessary.

(5) MUCOUS STERTOR, due to the bubbling of air through mucus which has collected in the trachea and larger tubes, and

(6) LARYNGEAL OR TRUE STERTOR, which is caused by the vibration of the vocal cords; and, during the administration of an anæsthetic occurs only in a deep stage. (It also occurs in such pathological conditions as apoplexy, but these do not concern us here.)

Dr. Bowles points out that stertor indicates obstruction, and it is therefore important to remove it as quickly as possible; for, if it be allowed to go on unrelieved during a prolonged operation, serious complications are likely to arise.

In addition to the results that anæsthetic vapours produce directly on the respiration, certain phenomena may arise during an administration due to other influences. Thus, *asphyxia* may be brought about by: (*a*) tight clothing or bad position of the patient; (*b*) swellings pressing upon the air-passages or encroaching upon the chest cavity; (*c*) pulmonary or cardiac disease, pleurisy, &c.; or (*d*) keeping an inhaler on the patient's face for too long a time without admitting air.

On the other hand, as Dr Hewitt has demonstrated, "*physiological apnœa*" may very easily be produced during an administration of nitrous oxide gas with oxygen, by giving too large a proportion of oxygen with the gas. The blood supply to the respiratory centre has also a marked effect on the breathing; and, lastly, alterations of the respiratory functions may be caused by the surgical procedure, especially the stretching of the sphincter ani, or by simple traumatism, as is seen in the *deeper breathing* that usually occurs when the first incision is made in a case which has been kept waiting some little time before the surgeon is ready to commence. Instead, however, of the respiration becoming deeper, *reflex spasm and obstruction* may be caused, especially if the patient be too lightly anæsthetised. Tearing a tumour away causes a greater reflex effect on the breathing than cutting; and the distension of the bladder with fluids nearly always causes marked reflex spasm.

The actual *rapidity* of the breathing at any given moment is of some practical importance. In the earlier stages of anæsthesia, a neurotic patient will frequently breathe extraordinarily quickly for a time, and then the respirations gradually become shallower, and finally cease for several seconds. This cessation is entirely due to the excessive amount of oxygen that has collected in the system during the rapid breathing, and calls for no special treatment, as the normal breathing will soon recommence by itself. Rapid breathing in the later stages, on the contrary, signifies the need for more air and less anæsthetic.

The respiration of an average patient in full surgical anæsthesia is of about ordinary frequency (or slightly quicker), deep, regular, and accompanied by some stertor. Very deep breathing denotes want of oxygen, but shallow breathing may be either the precursor of vomiting, from allowing the patient to come round too far, or it may be a symptom of commencing paralysis of the respiratory centre in the medulla. In order to distinguish between the two, it will be necessary to study the signs of the various stages of anæsthesia, which will be treated of later. In either case, it should be corrected as quickly as possible, for the extent of the respiratory movements has a considerable effect upon the heart's action.

During anæsthesia, there is a gradual diminution in the amount of oxygen consumed by the patient, and in the amount of carbonic acid produced; and this is held by some to be the reason of the notable fall that occurs in the temperature of the body, though other factors probably assist in causing this cooling; especially the exposure of part of the body, and the absolute immobility and condition of rest that obtains. It is more marked during etherisation than when chloroform is used.

EFFECTS ON THE CIRCULATORY SYSTEM.

According to most authorities, anæsthetics enter and leave the blood without causing any alteration in its chemical composition, except such as may arise from deprivation of oxygen. Turnbull,[1] however, states that "Etherization produces a marked diminution in the hæmoglobin of the blood," and Reicher,[2] who has

[1] "Artificial Anæsthesia," by Lawrence Turnbull, p. 223.

[2] *Lancet*, January 25, 1908, p. 268.

recently been experimenting on dogs in Berlin, finds a considerable increase in the amount of fat (up to three times the normal quantity). He also finds an increased amount of acetone, due to the disintegration of fat and albuminoid bodies.

The effects of anæsthetics on the heart and on the blood-pressure, however, vary according to the drug employed. Nitrous oxide gas causes a marked increase of the blood-pressure, and has no depressing action on the heart until after the respiration has become severely affected. Dr. Hewitt remarks that the heart's action becomes more and more accelerated as the administration of nitrous oxide gas proceeds. Ether stimulates cardiac action until very deep narcosis is produced, when the stimulation is replaced by slight depression. Ethyl chloride, according to Dr. Embley,[1] is a cardiac and vaso-motor paralysant. It increases the vagal action, but does not seriously impair the heart's spontaneous excitability. He thinks that respiratory failure is usually secondary to circulatory failure and fall of blood-pressure. Dr. Embley's results, however, do not agree with those of many practical anæsthetists; so we must await further investigation before making definite physiological statements. Clinically, in the human subject, the respiration appears almost always to fail before the heart. With an experience of nearly 2,000 cases, Dr. McCardie had never seen any sign of syncope, and my own experience is the same; such cases have,[2] however, been reported. The pulse, so far as one can tell by feeling it, remains as full and strong dur-

[1] *Lancet*, December 29, 1906, p. 1802.

ing ethyl chloride anæsthesia as before, and the heightened colour of the face would indicate that there can be no great fall of blood-pressure. Koenig finds that the arterial pressure is lowered in dogs and monkeys ; also that during deep narcosis the vagus loses its excitability. His experiments, however, were carried out by the old method of holding a compress over the mouth and nose. McCardie[1] denies that the blood-pressure is lowered.

Drs. Malherbe and Laval, of Paris, find that repeated doses of ethyl chloride on several days cause fatty degeneration of the heart, liver and kidneys, which continues to increase after the cessation of the administrations.

It is, however, when we pass on to the action of *chloroform* upon the circulatory system that we reach the real sphere of serious discussion, where different observers have obtained absolutely opposite results, and both sides have placed different interpretations upon each other's results. As I am a clinical anæsthetist and not a physiologist, I hope to escape the condemnation of the ultra-loyal supporters of the Hyderabad Commission by confining my personal views to the clinical aspects of the case, and giving the purely physiological findings of others, for which I am not responsible. Fortunately, both sides agree on one point, namely, that a fall of blood-pressure occurs during chloroform anæsthesia ; this is absolutely proved by numerous tracings obtained by the Hyderabad Commission, the Glasgow Committee, and others. There is temporarily a slight stimulation of

[1] *Lancet* April 4, 1903.

the cardiac action when chloroform vapour is first presented to a patient, but this soon gives place to a steady and progressive fall of the blood-pressure. The Glasgow Committee attribute this fall of pressure, in at least some of the cases, to the direct action of chloroform upon the heart; whereas the Hyderabad Commission deny that there is any such direct action, and declare that it is solely due to narcosis of the vaso-motor system, and is Nature's safeguard against the absorption of an over-dose by the blood circulating in the lungs. MacWilliam believed it to be due first of all to vaso-motor depression, and secondarily to dilatation of the heart, which commences when the corneal reflex disappears, and can be dispelled by ether. Gaskell and Shore[1] performed a number of cross-circulation experiments, as the result of which they describe an initial rise of blood-pressure due to stimulation of the vaso-motor centre; and a subsequent fall due chiefly to the effect of the chloroform on the heart itself, and not to an effect on the vaso-motor centre, which they say is stimulated and not depressed. Hewitt[2] states: "It is now, in fact, generally agreed that the fall of pressure under chloroform is chiefly dependent upon effects produced by chloroform upon the heart itself." Dr. Embley and Professor C. J. Martin[3] point out that dogs are specially liable to die suddenly from cardiac syncope during the induction period of chloroform anæsthesia. They performed experiments on the isolated heart, and

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[1] *British Medical Journal*, January 21, 1893.

[2] "Anæsthetics and their Administration,' p. 87.

[3] *Transactions of the Society of Anæsthetists*, vol. v.

found that the efficiency of the heart muscle rapidly diminished under the influence of chloroform, and recovered again perfectly after the chloroform was stopped. They therefore conclude that the heart muscle is extremely sensitive to the action of chloroform. But, in their experiments on the isolated heart, they never found any indication of *sudden* failure, though sudden circulatory changes do occur when the vagi are intact; and the cutting of the vagi causes the circulation to recover itself entirely. As soon as this happens, the respiration will likewise recover; in fact, the action of chloroform resembles stimulation of the vagi. Embley and Martin draw the following conclusions regarding the effects of chloroform on the heart: (1) It has an immediate and progressively paralytic effect on heart muscle, with no early stimulation; (2) nothing sudden ever happens to the rate of the heart-beats if the vagi be cut beforehand, or paralysed by means of aconite; (3) when sudden change in the rate or cessation of beat occurs at any period of anæsthesia, it always disappears on the vagi being cut.

In France, chloroform is much more generally used than in England, and Dastre, a French physiologist definitely states his opinion in the following terms: "The real danger of chloroformization comes from the heart and not from the respiration. It is, moreover, from the condition of the heart that the chief contra-indications arise." But he further declares that arrest of the heart's action is due to excitation and not to paralysis; so apparently his remarks refer to cases in which death occurs in the early stages of chloroform anæsthesia.

Snow's opinion was that primary cardiac paralysis only took place with high percentages of vapour; and that, if such concentration were avoided, the heart only ceased to beat secondarily to stoppage of the respiration; and this is the opinion of most English anæsthetists. That fatal primary cardiac failure does occasionally occur is quite certain, but in the vast majority of cases it is the breathing that first actually ceases; though this is always associated with a want of proper cardiac action: and in this connection it must be remembered that there may still be irregular contractions of the heart muscle after the heart has ceased to be of any service for pumping blood through the system.

An important point to remember is that *asphyxia* produces vagus inhibition of the heart, just as chloroform does: hence if the stimulus of asphyxia be superadded to the increased excitability of the medulla due to chloroform, vagus inhibition is much more likely to occur than if there be no asphyxia present. As Professor Martin points out, "Vagus inhibition means failure of the circulation and consequent medullary asphyxia, which will itself increase the inhibition." One has then entered a vicious circle, and this is the reason why careful attention to the respiration is so essential.

Dastre[1] describes what he terms chronic chloroformization, by which he means the frequent anæsthetization of the same patient on successive days. He describes a series of experiments by Paul Bert on a dog for thirty-two days in succession, chloroforming it for thirty-five minutes each day at the same

[1] Dastre, "Les Anesthésiques," p. 98.

hour with a mixture of 10 per cent. of chloroform vapour in air. He found that the induction period never varied, but that the struggling in the early stages became gradually less, and the anæsthesia more tranquil as the animal became more accustomed to the process. The appetite failed, but thirst increased, and after the twelfth day drowsiness became continuous. It died during the administration on the thirty-second day, having lost 28 per cent. of its weight. The muscles were atrophied and pale; bile pigments were passed in the urine and the elimination of urea was increased, but the urine never contained albumin, sugar, or chloroform. These results do not quite agree with my own, but as my patient was a human being, I could not arrange matters with so much precision as M. Paul Bert. During the late war in South Africa I anæsthetized one Colonial officer eleven times in sixteen days, using plain chloroform each time. The hour of day was not always the same, nor was the external temperature. This patient had slight vomiting afterwards on five occasions, four of which were the last four administrations, though on the first two occasions he was not prepared for an anæsthetic. The time occupied in inducing anæsthesia steadily decreased from twelve minutes on the first day to eight minutes on the last. Struggling likewise showed a gradual diminution. The amount of chloroform required to bring about full surgical anæsthesia gradually increased for the first four administrations and then steadily fell, until, on the last day, he only required one-third of the quantity that was necessary on the fourth day. The amount of chloroform required for keeping up the anæsthesia after the induction stage was passed showed no appreciable change from first to last.

EFFECTS ON THE NERVOUS SYSTEM AND MUSCLES.

We now pass on to the consideration of the system upon the condition of which the anæsthetic state really depends, and we find that those parts which have the most complicated functions are the first to be affected. It has been shown that loss of sensation primarily depends, not upon changes in the sensory nerve terminals, nor in the nerves themselves, but in the centres in the brain ; likewise loss of movement is caused by similar changes in the motor centres. Further, these various centres are always affected by anæsthetics in a certain definite order, which is of the utmost importance to the safety of the patient. It is owing to this regular and definite sequence of events that we are enabled to judge of the exact stage or degree of anæsthesia that exists at any given moment ; and it is therefore in this connection that we will presently consider the signs and symptoms of the five stages of anæsthesia as first described by Snow. If any drug paralyzed the cardiac or respiratory centre before it destroyed sensation to pain, it would obviously be absolutely useless.

We find that the *cerebrum* first becomes affected and volition is lost ; so that movements apparently purposeful may still take place reflexly, but the actions are no longer designed or controlled by the intelligence of the patient. Next, the *sensory tracts in the cord* are attacked, as a result of which the movements become erratic and not even responsive to sensory stimuli. After these the *motor tracts in the cord* are anæsthetized, which puts an end to all movements; and finally, the *medullary centres* which preside over respiration and the heart's action are paralyzed if the anæsthesia be pushed far enough.

The very first effect of an anæsthetic upon most people is to cause them a peculiar feeling of numbness or tingling in the fingers; this usually commences after a few breaths of the vapour or gas, and is most noticeable during an administration of nitrous oxide gas and oxygen. After this, consciousness begins to become disordered: words spoken by bystanders are liable to be misinterpreted by the patient, and may result in struggling or even violent fighting. Consequently, it is important that the induction of anæsthesia should be carried on in absolute silence. Nor is it only sounds that may be misinterpreted; any movement of the couch, or the raising or lowering of a dental chair, or even touching the patient in any way, such as taking hold of his wrist to feel the pulse, or commencing to loosen bandages, will frequently be the cause of struggling owing to the patient not understanding the real meaning of what is happening.

Sometimes the movements which arise in response to an external stimulus, such as drawing up the leg when pinched, may appear to be purposeful; but this is not so, or at least if the administration be stopped at this stage the patient will have no remembrance of the movement. The same remark applies to his words, which is an important point; for after the patient has taken a few breaths of the vapour, even should he object or refuse to be anæsthetized, the induction should be persisted in, as he is not at this stage responsible for his words or actions.

If, instead of being comfortably seated in a chair or lying on a couch, the patient be not properly supported, he will fall from the loss of ability to maintain his equilibrium—not from any loss of motor power as his subsequent struggling may demonstrate. It is doubtful whether a true analgesia ever occurs in this stage before consciousness is lost, though such a state has been described; and it is utterly impossible for a patient to lose the power of moving whilst still retaining consciousness. In the early days of anæsthetics some medico-legal cases gave great trouble from this fact not having been definitely settled.

It would be difficult to test accurately the order in which the special senses are destroyed. Sight appears to go before hearing; and probably the sense of taste lasts longer than either of these; at any rate, young infants will frequently continue to lap up the sweet chloroform vapour with their tongue after they are apparently quite unable to see or hear. It is at least absolutely certain that the sense of hearing returns before the sense of sight, and whilst the patient is still analgesic, after brief operations under nitrous oxide gas. I have myself heard remarks made while one of my teeth was being extracted during recovery from gas, though I felt nothing, and knew nothing of the operation. The sense of sight seemed to return very shortly afterwards.

After the sensory centres, the motor system begins to be affected, also in a definite order, commencing with the motor centres in the cortex; then the motor tracts in the cord; next the motor nerve fibres, and lastly the muscles. So we find that in the early stages of the administration, complex and apparently purposeful movements occur as the result of stimuli; then the movements that occur lose their apparently purposeful nature; and when the motor centres are completely paralyzed, so that no movements can originate spontaneously, and there is complete muscular relaxation, irritability of the nerves still remains even during deep surgical anæsthesia. This is frequently and usefully demonstrated by twitchings of the muscles of the face during a mastoid operation, when the facial nerve is touched; and this fact frequently saves the patient from permanent facial paralysis, by giving good warning that the nerve is in danger. The recovery of the functions of the different parts of the motor system occurs in the inverse order.

Tonic muscular spasm of a few muscles or of the whole system may occur during anæsthesia, especially during induction: if it occur during deep anæsthesia it is usually asphyxial in origin, but it may also be caused reflexly by certain kinds of stimulation, such as dilating the anus. During induction, breathing may be interfered with, or actually cease from spasm of the larynx, due to the vapour being too concentrated, or from spasm of the muscles of the chest wall during the struggling stage.

Clonic muscular spasm also occurs during light anæsthesia, and is usually caused by want of oxygen; it is most commonly seen in nitrous oxide anæsthesia, but it may also occur apart from asphyxia, in early ether narcosis, and is then sometimes known as "ether tremors"; but it passes off on pressing the anæsthetic or on changing to chloroform. These tremors also occur fairly frequently while a patient is coming round after chloroformization, and may then be confined to one limb, or they may be unilateral or general. Vertical nystagmus is the rule rather than the exception during induction with nitrous oxide and oxygen.

The condition of the **reflex movements** in the various stages of anæsthesia is of great practical importance, as it is largely upon these that the anæsthetist depends for his knowledge of when to give more or less of the drug, or to continue as he is doing.

During induction, when the cerebral control is first interfered with, the reflexes are exaggerated ; but as deeper anæsthesia supervenes, they gradually become less active, and are finally abolished in a fairly definite and regular order. As has already been stated, in the early stages, even after consciousness has been lost, reflex movements *appear* to be purposeful for a time ; but soon lose all such appearance. This statement, however, applies to such movements as may be occasioned by tickling or pinching the skin : the conjunctival and corneal reflexes are always the same in kind so long as they exist. As the reflexes become feeble, or even shortly after they have been abolished, especially during early chloroform anæsthesia if the breathing be allowed to get shallow, they may at once return if a prick, or cut, or some such irritation be applied to any other part of the body, or if the lips be briskly rubbed with a rough towel.

The order in which the reflexes are abolished is approximately as follows :—

(1) Superficial skin reflexes.
(2) Patellar and plantar reflexes.
(3) Vomiting.
(4) Swallowing and retching.
(5) Coughing.
(6) Phonation.
(7) Conjunctival.
(8) Corneal.
(9) Light and lachrymal.
(10) Bladder and rectal.
(11) Lip reflex.
(12) Respiratory.
(13) Cardiac.

This table is given as a rough guide; but it is not suggested that the reflexes must necessarily always disappear in this exact order, nor that they will always reappear in the inverse order; and as I have never seen a table of this kind drawn up by any other anæsthetist, it may be that opinions will be found to differ somewhat.

The table becomes useful when we wish to know the depth of anæsthesia required for any given operation. For example, for an operation on one of the extremities, anything below No. 7 would suffice. A lighter anæsthesia would be undesirable, though perhaps possible, for vomiting might not necessarily prevent the operation being performed, but it would be at least unpleasant, and might cause danger from depression of the heart. On the other hand, phonation to a certain extent, and a conjunctival or corneal reflex would not inconvenience anyone. Now, if the operation be upon the rectum instead of upon a limb, all reflexes down to No. 10 on the table must be abolished;

and the risks of the anæsthesia are proportionately increased, for we are now as near the limit as it is possible to go, and great care has to be taken: such a depth of anæsthesia should not be attempted by anyone who has not had a large experience of this kind of work. Likewise, during eye operations, it is essential that at least the first eight reflexes be abolished.

The best stage to reach for ordinary general surgery is that which exists when the first seven of the above-mentioned reflexes are abolished; that is to say, when the conjunctiva is insensitive and there is no coughing or retching; but the corneal and light reflexes are still present. In certain special operations, however, such as those of rectal, gynæcological, ophthalmic, and abdominal surgery, the corneal reflex must be abolished, and generally also the light reflex. During an operation, a patient should not be allowed to regain his swallowing reflex; and if any swallowing movements be observed, the anæsthetic must be immediately pressed, otherwise vomiting is likely to occur.

A reflex of great practical importance is reflex spasm of the larynx. Gardner[1] tabulates the causes of this condition under the three following headings:—

(1) The direct irritation of the cords by the vapour, most frequently ether.

(2) The presence of mucus, blood, pus, or a foreign body in the larynx.

(3) The powerful stimulation of peripheral nerves; as for instance by stretching the sphincter ani.

Each of these requires special treatment, which will be considered later.

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[1] "The Asphyxial Factor in Anæsthetics," p. 24.

The only remaining effects of anæsthetics that need consideration are those on the natural **secretions** of the body. Nitrous oxide, according to Kemp[1] causes contraction of the renal vessels, and diminution of the *secretion of urine*. He further states that slight albuminuria occurs in deep anæsthesia. With ether his results are similar, with the exception that albumin appears earlier in the administration. Dr. Belfrage[2] records a case of death from suppression of urine after a three hours administration of ether, and others are also on record. Dr. Chase[3] examined the urine of several patients before and after etherization, and found that in nearly every case on the day following the operation the urine was more concentrated than before, the specific gravity rising about ten points ; and the amount of chlorides, phosphates and urea was increased. He further found a large number of casts in proportion to a small amount of albumin. The urine begins to clear up on the second day, and by the end of a week it is usually back in its normal condition. He found more or less albumin in three out of every four cases which he examined ; and two of his patients died from suppression, neither of whom had previously suffered from any kidney trouble.

Chloroform has less action on the renal functions, and does not lessen the secretion until the general circulation has become depressed ; and albuminuria only occurs after prolonged chloroformization. Patein (*Thèse de Paris*, 1888) states that chloroform causes

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[1] *New York Medical Journal*, November, 1899.

[2] *Transactions of the Society of Anæsthetists*, vol. v.

[3] The *Post-Graduate*, March, 1904.

albuminuria in one out of every three cases. Repeated administrations of chloroform on several successive days, moreover, cause fatty degeneration of the liver, kidneys, heart and other organs, and increased elimination of urea. Ethyl chloride does not appear to have any effect upon the renal secretions, but further investigation is required on this subject.

The *salivary secretion* is increased during light and moderately deep anæsthesia, especially by ether; but is diminished and finally stopped in very deep narcosis. The same remarks apply to *lachrymation;* except that ether does not stimulate the lachrymal glands more than other anæsthetics do.

The activity of the *sweat glands* does not appear to be specially affected by anæsthetics except ethyl chloride, which frequently causes somewhat profuse sweating. Otherwise, if much perspiration occurs, it is usually due either to cyanosis or severe shock.

STAGES OF ANÆSTHESIA.

For convenience, the actions of anæsthetics are usually classified into five stages or degrees of anæsthesia. Snow originally classified the results of inhaling anæsthetic vapours into five degrees, but some writers only describe four, and make them overlap at different places. Dastre,[1] for instance, gives the following classification :—

First period.—Suspension of the functions of the brain, producing sleep.

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[1] "Les Anesthésiques," p. 36.

Second period.—Abolition of the sensory conduction of the cord, producing complete anæsthesia.

Third period.—Abolition of the motor conduction of the cord, producing inertia and muscular resolution.

Fourth period.—Affection of the bulb, causing cessation of respiration and arrest of the heart.

Most English and American writers, however, still describe five degrees, as follows :—

The **FIRST STAGE,** or that of **disordered consciousness,** is that in which consciousness still persists, but volition and thought are deranged. The hearing is acute, reflexes are exaggerated, and external impressions are liable to be misinterpreted ; the patient is not responsible for his words or actions, nor will he remember them. He becomes emotional, and may laugh, cry or sing, and if not properly supported he will fall. There is numbness of the extremities, and a feeling of fulness of the head, with buzzing in the ears, and some diminution of common sensibility. Dreams occur at this stage, and have led to serious accusations against the administrator ; hence, no anæsthetic should be commenced without a third person being present, especially if the patient be a female. The heart's action is increased and may be very quick from the influence of fear ; and from the same cause the face may be pale, though the blood-pressure soon rises. An injury at this stage may stop the heart's action. The breathing is usually increased, but is liable to irregularities from the irritation of the vapour causing coughing or holding of the breath, swallowing, or occasionally retching. The eyeballs are mobile, and the pupils are variable, with a tendency to dilate, and they react to light ; while the conjunctival and corneal reflexes are very brisk. The knee-jerks and ankle-clonus are well marked.

The **SECOND STAGE** is what is commonly known as the **excitement stage.** Consciousness, at first exalted, is soon lost and the speech becomes inarticulate. There may be struggling or general muscular spasm, and the breathing may be more or less interfered with by spasm of the glottis, or masseter muscles, or even of the chest muscles; the tongue may also be spasmodically drawn back against the posterior pharyngeal wall. The secretion of mucus and saliva is increased, and swallowing movements are frequent; lachrymation also is excessive. Respiration becomes deeper and at the same time irregular. It is in this stage that the "ether tremors" occur. Sensation to pain is nearly abolished. The pulse becomes fuller and stronger, and the colour of the face is heightened. The coughing and vomiting reflexes persist, as do also the conjunctival and corneal reflexes, but they are not so brisk as in the first stage. The eyeballs roll about, and the pupils dilate from stimulation of the sympathetic nerve.

The **THIRD STAGE** is the stage of **surgical anæsthesia.** In this stage there is general muscular relaxation, though some rigidity may persist for a time, especially over a diseased area. Consciousness is entirely abolished, and there is no sensibility to pain, nor are there any reflex movements in response to a skin incision. The breathing is regular and automatic, and soon becomes stertorous. The pulse becomes regular and bounding with ether, and slow but full with chloroform. The colour of the face and lips should be about normal. The coughing, vomiting and swallowing reflexes are absent, and phonation gradually subsides. The eyes become fixed and moist, the pupils contract from stimulation of the third nerve, and the conjunctival reflex is lost. Later, the corneal reflex also disappears, and the pupils relax from commencing paralysis of the third nerve; while the eye loses its glossy appearance, and the conjunctival vessels at the same time become congested.

In the **FOURTH STAGE** the breathing is regular and accompanied by deep stertor; or it may be feeble and shallow, depending chiefly on the type of patient, and partly also on the anæsthetic employed. The muscular system is entirely relaxed, including the abdominal muscles, provided the respiration be not obstructed. The pulse tends to become irregular, and with chloroform very slow; while the colour of the face becomes pale or a little blue. The eyes are fixed, and often rotated upwards, and the lids separate, the lid-reflex is entirely absent, and the pupils dilate widely from paralysis of the third nerve; there is therefore no light reflex possible: and lachrymation being entirely suspended, the eye becomes dry and sticky, and presents the appearance of that of a corpse.

As the **FIFTH STAGE** is approached, the bladder and rectal reflexes are abolished. Breathing is shallow, the inspirations are divided, and friction of the lips no longer reflexly stimulates the breathing. The pulse becomes more irregular and feeble, and the colour of the face is livid. The breathing then ceases, from paralysis of the respiratory centre; and lastly the heart's action is also arrested, and death supervenes.

The last stage is of course never produced intentionally in the human subject, but for the sake of greater clearness, a short and practical, but necessarily incomplete, table is appended, showing the chief signs of each of the first four degrees. It must only be taken as approximate, because the transitions from one stage to another are gradual and progressive, and not always absolutely regular in every detail.

	First Stage	Second Stage	Third Stage	Fourth Stage
Consciousness	Disordered	Exalted ...	Absent ...	Absent.
Painful sensations	Diminished	Nearly lost ...	Absent ..	Absent.
Respiration	Variable ...	Deeper ...	Regular; automatic	Deep stertor; or feeble and shallow
Pulse ...	Rapid from fear	Fuller and stronger	Regular; bounding with ether, slow but full with chloroform	Irregular; or with chloroform very slow.
Colour of face and lips	May be pale from fear	Heightened	Good	Pale or blue.
Eyeballs ...	Mobile and moist	Mobile and moist	Fixed and moist	Fixed and dry.
Pupils ...	Variable ...	Dilated, from stimulation of the sympathetic	Moderately contracted, from stimulation of the 3rd nerve	Dilated, from paralysis of the 3rd nerve.
Light reflex	Brisk ...	Brisk ...	Less brisk ..	Absent.
Lid reflex ...	Brisk ...	Brisk ...	Less brisk, to absent	Absent.
Coughing and vomiting reflexes	Present ...	Present ...	Absent ...	Absent.

Having arrived at this point, we may now consider what is the proper depth of anæsthesia to maintain during an ordinary surgical operation, and how to know if the anæsthesia be getting too light or too deep. The procedure required in special cases will be described later. In actual practice, one must not expect to find every symptom so regular and definite as in the above table, but the administrator must be guided by the majority of the signs present at any given moment: and if he be in doubt as to which of them he is to consider as showing the true state of the patient, he should always place his chief reliance on the breathing. Some writers declare that the breathing alone should be watched, and that if other signs also be observed, some of the administrator's attention, which should be concentrated on the breathing, is thereby removed. But a person of average intelligence ought to be able to watch more than one sign at a time; and even without troubling to feel the pulse, it is very simple to note the colour of the patient's face, ears and lips, which gives a fair indication of the state of his circulation; and at the same time it shows whether the supply of oxygen be sufficient. Similarly, an occasional glance at the patient's eyes cannot remove the administrator's attention from the respiration to a dangerous extent. And it is on these three signs—the respiration, the colour of the face, and the state of the eyes—that most anæsthetists depend for their indications during an ordinary operation; the other points mentioned are mainly kept in reserve for special or doubtful cases.

In a **Good Normal Anæsthesia** the respiration should be regular, deep and softly stertorous, and the muscles of the extremities should be lax. The colour of the face, ears and lips should be about normal;

neither pale nor blue. The eyeballs should be fixed and moist; the pupils moderately contracted, but not too small, and should react to light; and the lid-reflex should be almost, if not quite, abolished. There must, of course, be no muscular movements on the part of the patient, nor coughing or vomiting.

The **Signs of Returning Consciousness** are weak breathing, pallor of the face, and swallowing. If swallowing movements be noticed, the anæsthesia must be pressed at once; otherwise vomiting will take place. Expiratory phonation may be heard. The eyeballs begin to roll about, and later on to make rapid movements from side to side; the pupils dilate and react to light, the lid-reflex returns and becomes brisk; and lachrymation is excessive, so that tears begin to overflow.

The **Signs of Deepening Narcosis**, on the other hand, are weak respiration, with a dusky appearance of the face, and no swallowing movements; flaccidity of the muscles; soft, feeble pulse, becoming irregular, and slow with chloroform. The eyeballs are fixed and dry, the pupils dilate and do not react to light, and the corneal reflex is absent.

Anæsthetists vary a little in the depth of anæsthesia that they prefer for their average cases, and some think that the above is more profound than it need be; but if the patient be too lightly under, there is a greater liability to sudden shock, and reflex interference with the breathing will be more common.

CHAPTER IV.

PREPARATION FOR AN ANÆSTHETIC.

A.—Personal Preparation of the Patient.

If the operation be not an urgent one, the preparation may commence several days previously by preventing any excesses either of eating, drinking, or smoking, by keeping early hours, and ensuring at least one free action of the bowels each day. If there be *albuminuria* or *glycosuria*, these should, if possible, be controlled and brought to a minimum before the day fixed for the operation. In a large number of cases, however, the patient will not submit to any interference with his normal habits for many days. Under these circumstances he should take a purgative, a small dose of castor oil or calomel for preference, two nights before the day arranged for the operation, so as to clear the bowels well one day previously; too strong purgatives should be avoided as they cause exhaustion. An enema on the morning of the operation will then empty out what remains in the rectum, and there need be little fear of any further action during the administration, which is a very likely consequence of giving the purgative only one night previously, especially as some patients are violently purged by a dose which might even fail to act as a mild laxative on another person. The above treatment need not be enforced before a dental operation under nitrous oxide gas: in this case nothing more than a healthy action of the bowels each day is required. The *bladder* should always be emptied immediately before the induction is commenced, for children frequently, and adults sometimes, micturate when anæsthetised even by nitrous oxide gas, especially if cyanosis and jactitation occur.

The best **hour for the administration** is the patient's usual breakfast hour, for the stomach is then empty, and the patient has not yet begun to feel the want of food. On the preceding day the meals need not be interfered with so long as excesses be avoided; and it is better to omit the most indigestible portions of the evening meal. The night's rest will then make the patient fresh and comparatively cheerful by the time the operation commences; and this should be punctual. The patient should on no account be awakened at about 6 o'clock in the morning to drink a cup of milk or other food, for the stomach is not accustomed to digest food at this hour, and will certainly not do so on a day of such anxiety.

If the patient's breakfast hour cannot be arranged for the performance of the operation, the next best time is his luncheon hour; for in this case he can partake of a light breakfast at the usual time, which will be mostly digested before lunch time, and yet there will have been no *unusual* period of starvation.

Unfortunately, it is not possible to operate on every patient exactly at his meal times; so, in these other cases, special arrangements must be made, and a good general rule is to allow no milk or solid food within three or four hours before nitrous oxide gas or ethyl chloride ; or within five hours before chloroform or ether ; and the best kind of food under these circumstances for the last meal is strong beef tea or meat essence, as this is easily digested and leaves no residue in the stomach, whereas milk is liable to curdle and be vomited up. It should be borne in mind that the process of digestion is rendered slow and is considerably interfered with before an operation, owing to the nervous depression of the patient.

If the patient be in a feeble condition it is prudent to diminish the length of the fast in accordance with the requirements of the case ; otherwise exhaustion and faintness will be added to the ordinary risks of the operation. The same remark applies to elderly people ; but in the case of young infants, no alteration whatever need, or should, be made in the usual diet, either as regards quantity, quality or time, for they are hardly ever sick during or after anæsthesia, and are very liable to exhaustion if starved.

Stimulants should not be given as a routine in all cases before an anæsthetic ; in fact, the majority of people do much better without them. Should the patient be very feeble and chloroform is to be given, about half an ounce of brandy in an equal quantity of water may be administered with advantage half an hour or so before the operation. If, however, ether be the anæsthetic chosen, it is best to withhold all stimulants. A beef-tea enema containing brandy may be injected about half an hour before the operation if there be much exhaustion.

In certain **special cases** special preparation is required, or at least may be beneficial. Thus, in cases of *intestinal obstruction* attended by severe vomiting, it may be advisable to wash out the stomach with warm water before commencing the anæsthetic. This may be done by passing a stomach-tube, or sometimes, if the vomiting be very frequent, by simply giving the patient some warm water to drink, and leaving Nature to do the rest. This method will be found to cause the patient less distress than the passing of a tube would. In such cases a small prop should be placed between the teeth; the patient's head, and if possible his whole body, must be kept turned completely to one side throughout the administration of the anæsthetic, and during recovery, in order that the contents of the stomach may escape freely and not be inhaled into the lungs; and it is sometimes well to pass a tube and wash out the stomach at the end of the operation before the patient is removed from the table. Purgatives must of course be avoided, but a simple enema may be employed.

Before some cases of *cystoscopy*, the patient is made to drink a large quantity of saline solution, but I have never found that this has any effect on the natural course of the anæsthesia.

Extremely exhausted patients and *cardiac cases with symptoms of failure of compensation* may be given brandy by the mouth, or a hypodermic injection of strychnine or brandy shortly before commencing the anæsthetic. A nutrient enema containing brandy is often efficacious in these cases, and sometimes an injection of saline solution into the loose tissues of the axilla, or directly into a vein is of great service. The starvation beforehand had better be dispensed with, but the last feed should consist of beef-tea or clear soup rather than of milk. If there be distress on lying down, the patient should be well propped up with pillows on the table during induction; and these can be removed one by one later on if necessary. Hot bottles and plenty of warm blankets should be used, and the temperature of the room should be higher than is required for most other cases, about 75° F.

Before *operations on the brain*, some surgeons like to give an injection of morphia; this affects the ordinary signs of anæsthesia to some extent, and will, therefore, be fully considered in a later chapter, as also will the spraying of cocaine into the nose and throat, or into a wound. The application of cocaine to the eye before *eye operations* only concerns the anæsthetist, inasmuch as it abolishes the lid-reflex, and causes dilatation of the pupil, which may lead the administrator to think that the anæsthesia is deeper than it really is.

The **Clothing** should be loose, light and warm. In the case of a major operation this is simple enough, but many patients will endeavour to escape loosening their clothes before taking gas for tooth extraction. There should be no tight bands round the neck, chest, or abdomen; and it is necessary to remember that bands which are fairly loose before the operation may become tight owing to some change of posture during the operation. Heavy coverings may also interfere with the free respiration of a feeble patient under an anæsthetic.

All unnecessary exposure of the body surface must be avoided. A certain amount of loss of heat always occurs during anæsthesia, especially with ether; but it is very important to limit this loss as far as possible, so as to diminish the shock, and the risk of bronchitis or pneumonia afterwards. Respiratory complications are most common after abdominal operations; and this is due in great measure to the large surface exposed. In these cases, a shawl or small blanket can be placed over the chest without inconveniencing the operator, and the legs also may be covered with thick stockings and a warm blanket. It may sometimes be advisable to wrap up the arms as well.

B.—Preparation of the Operating Table and Room.

The *table* must be strong, steady, and of a convenient length and height, and it is better if it be capable of being tilted so as to invert the patient should the necessity for such a procedure arise. It should be made as comfortable as possible for the patient by being well padded or hollowed out, and broad enough to allow of the arms lying along the sides of the body; otherwise they may slip down, and so lead to compression of the musculo-spiral nerve against the edge of the table, with resulting paralysis of the muscles supplied. The table should then be placed in a good position as regards light and general convenience, and out of all draughts.

The *room* should be large, bright, and well ventilated, but warm: about 70° F. is the most suitable temperature for ordinary cases. The atmosphere should not be allowed to get saturated with steam from the sterilizers, which should be outside, and not in, the operating room. The room should be lit, if possible, at the time of the administration, either by daylight or by electric light; the employment of candles, oil lamps or coal gas for lighting purposes is attended by serious risks, especially in a small and badly ventilated room. For, if we use ether, we run the risk of an explosion; and if we use chloroform, the vapour will be decomposed into hydrochloric acid and phosgene gas, which cause irritation of the eyes and air-passages, and may lead to bronchitis or broncho-pneumonia, not only in the patient, but also in the other occupants of the room.

The room should contain plenty of small tables for instruments, several basins of various sizes, and the bed on which the patient is to recover; for carrying him into another room not only exposes him to draughts, but also gives him a needless amount of shaking, which will probably cause vomiting.

C.—Examination of the Patient.

A careful survey of the patient is of great importance, for on this will depend the anæsthetist's decision as to whether it be safe to administer an anæsthetic at all, and also his choice of the particular drug to employ, and the most satisfactory method of procedure in any given case. The anæsthetist should notice how the patient walks into the room, if he *can* walk, and especially if he be out of breath or at all cyanosed. If, however, the patient be unable to walk, it should be noted whether there be any orthopnœa, or any obstruction to the respiration from a tumour or abdominal distension, or if the patient be markedly emphysematous or bronchitic. Further, the general bodily and mental condition, and the *apparent* age of the patient should be observed; the *actual* age is not so important. All these matters can be determined by a careful inspection without the patient being aware that any examination is being made. As a rule this inspection will be sufficient; but if there be any doubt, a thorough examination of the chest should be made in the ordinary way; and the degree of abdominal distension (if any exist) should be ascertained; but, if possible, avoid alarming the patient by too elaborate an examination, or by asking fussy questions. Next, the *pulse* should be felt, and attention paid to its frequency, strength and regularity; marked atheroma will be obvious, and there may be evidence of aortic incompetence or renal disease.

The patient should now be asked to open his mouth, and its interior must be examined. The simple question, "Have you any false teeth?" is not sufficient. The special points to notice inside the mouth are:—

(1) The present of any *foreign body*—false teeth or obturators in adults; or sweets, buttons, &c., in children.

(2) The presence of *loose teeth*, which may be dislodged during the administration. If there be any, their exact position should be noted, so as to avoid inserting a gag at that spot.

(3) The *regularity of the teeth*. If the teeth be set very straight, and fit well, the free air-way will be greatly interfered with when spasm of the masseters occurs; and if no teeth have been extracted, there will be no space in which to insert a gag if this be necessary. In both these cases, a small dental prop should be placed between the teeth before commencing the administration.

(4) The *size of the tonsils*, which, if much enlarged, may obstruct the breathing, especially if any method

of administration be chosen which would of itself cause congestion of the parts. The same remark applies also to

(5) The *existence of new growths* within the cavity of the mouth. A narrow, high-arched palate would indicate the probable existence of adenoid growths obstructing the nasal airway.

After examining the mouth, the anæsthetist should note whether the patient can breathe without difficulty through the nose. The size of the pupils may be observed, and the colour of the lips, ears and cheeks. The temperature chart also deserves some attention.

Finally, one hand should be placed on each side of the front of the chest, and the patient asked to take a deep breath. The amount of expansion or rigidity of the chest will make a great difference to the way in which the anæsthetic will be taken.

The patient may now be re-assured by a few words, and instructed how to breathe. These instructions are given, to a large extent, to occupy the patient's mind and so diminish his fear. Once the administration has been commenced, strict silence should be maintained until anæsthesia is complete: otherwise, struggling is likely to occur.

D.—Preparation of Instruments.

Before commencing the administration of any anæsthetic, and if possible before the patient enters the room, the anæsthetist should have all his instruments laid out ready at hand on a small table by the side of the head end of the operating table. His bottles should be ready filled, and an alternative anæsthetic must always be at hand; and the whole covered over with a clean towel, so as not to alarm the patient. The instruments, as well as the anæsthetist's hands, must be absolutely clean; but to be aseptic is a practical impossibility, inasmuch as the anæsthetist is bound to touch the patient and the coverings, as well as the outsides of his own botties, none of which can be sterilized. For operations about the head and neck, he should take all the precautions that he possibly can; and for mouth operations, his gags and mouth-tube should be boiled. In other cases, a thorough washing of all instruments with soap and running hot water will suffice. From the point of view of cleanliness, rubber inhalers which can be turned inside out are obviously preferable to those which cannot be so treated; these will be described later.

The actual instruments that should be in readiness will be detailed in the chapters on administration, and on the treatment of difficulties and dangers.

E.—Posture of the Patient.

Unless there be some special reason, no anæsthetic should be administered to a patient while sitting up in a chair, except nitrous oxide or ethyl chloride, for a short operation. In other cases, the recumbent position should be adopted. Under any circumstances, the patient should be made quite comfortable before the anæsthetic is presented to him. For ordinary surgical work, he should lie on his back, with the head turned well over to one side, so that any mucus can run out of the mouth freely, and the tongue will not gravitate backwards. The number of pillows under the head must depend upon the wishes of the patient, which must be considered as much as possible. Extra pillows can always be removed after consciousness has been abolished, if desired. As a general rule, a small and firm pillow should be placed under the head, so that the latter is in a straight line with the body. The side to which the head is turned may be chosen by the patient when the operation is below the middle of the body, but if it be above the level of the umbilicus, the face should be turned to the opposite side to that on which the operation is to be performed. This gives more room to the anæsthetist and to the surgeon, and lessens the risk of any of the surgeon's instruments coming in contact with the inhaler. During an administration, the position of the head should never be reversed, as this nearly always results in some respiratory embarrassment, owing to saliva and mucus running down to the back of the throat during the process.

The dorsal recumbent position with the head turned to one side is suitable for all ordinary operations on the neck, breasts, abdomen, or limbs; but there are many cases in which it is impossible. For example, if the abdomen be greatly distended, the respiration may be severely hampered unless the patient be sitting almost upright until the distension has been relieved. In some heart cases also the recumbent position may be impossible. Then again, during the operation for *cleft palate*, the patient may indeed lie flat on the back; but the head, instead of being turned to one side, must face directly upwards. Hence, in these cases, blood and mucus must be kept from entering the larynx by means of sponges, since they cannot run out of the mouth by themselves.

During operations on the *kidney*, or for *empyema*, and sometimes for *hip disease*, the patient is required to lie upon one side, and this is an exceedingly good position from the anæsthetist's point of view, provided certain details be attended to. Firstly, the legs should be drawn up with the knees bent, to prevent the

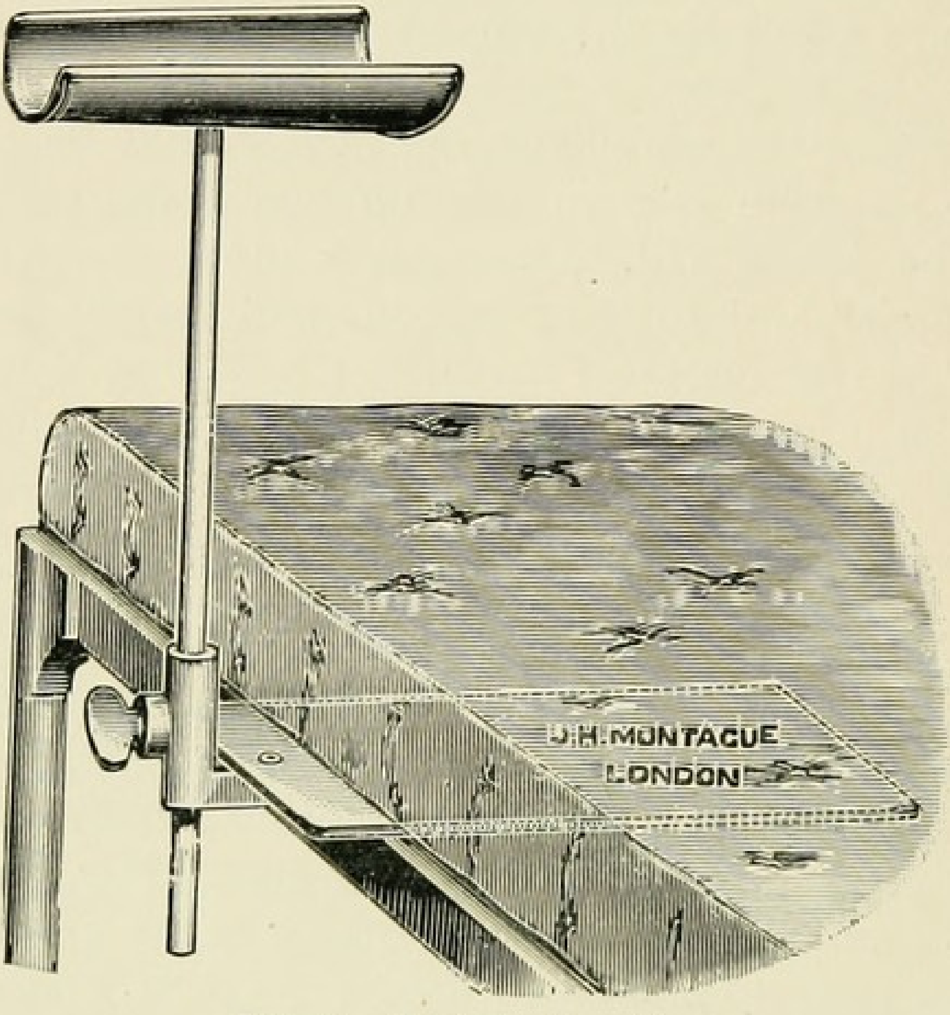

FIG. 1.—Braine's Arm Rest

patient rolling about. Secondly, the weight of the uppermost arm must not hang over the side of the table, and so interfere with free movement of the chest. Mr. Carter Braine has devised an excellent and simple apparatus for supporting the arm when the patient is in this position, which is shown in fig. 1. Lastly, the pillow must be rather higher than when the patient is lying on the back, and must be so arranged that the patient's face projects slightly beyond the end of it; otherwise the pillow will get in the way of the inhaler. In the case of *empyema*, if this position be the one chosen, the patient should lie on the diseased side, so as to leave the healthy side of the chest free to expand; and so that, in case the abscess communicates with the lung, the pus will not gravitate into the opposite bronchus.

Operations upon the *spine* may require the prone position, with the head turned to one side. Here, respiratory embarrassment may cause the anæsthetist great anxiety and difficulty; and the same remark applies to the lithotomy position, and to Trendelenburg's position, especially with an obese subject.

The special uses and difficulties of these various postures will have to be considered more fully in the chapters dealing with "Procedure in Special Cases," and "Difficulties and Dangers during Anæsthesia, and their Treatment."

CHAPTER V.

THE SELECTION OF THE ANÆSTHETIC, AND THE PROCEDURE IN SPECIAL CASES.

GENERALITIES.—The first consideration in this matter is the safety of the patient. Hence, this chapter may well commence with a few words on the relative degrees of danger that attend the administration of each of the anæsthetic agents in general use.

Chloroform undoubtedly stands first on the list with a death-rate of about 1 in 2,800. This average includes cases done in hot climates and at high altitudes, where chloroform is much less dangerous than in England; so the death-rate in this country taken alone would probably be considerably higher. Next to chloroform come the various mixtures of chloroform with ether or alcohol, or both; with these the death-rate is about one-half of that due to chloroform when used by itself.

The statistics for ethyl chloride have not been sufficiently worked out yet, but there have been many deaths reported during its administration,[1] and it may be presumed that others have occurred without being published. The death-rate is probably about the same as that due to ether, but it must be remembered that the drug is a recent innovation, and some of the patients who have died during its administration

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[1] *Lancet*, May 5, 1906, p. 1233.

would never have been given either ethyl chloride or any other anæsthetic which required the exclusion of air, if they had been in the hands of an experienced anæsthetist. Clover met with one death in 1,877 administrations.[1]

The death-rate from ether is about 1 in 16,000, so it is about five times safer than chloroform. If, however, we add on the number of deaths which occur from respiratory complications following ether administration, and the deaths that occur from "late chloroform poisoning," we shall find that the relative safety of ether is not quite so great as is shown by these figures.

Deaths under nitrous oxide gas are very rare—about 1 in 100,000—and when a death does occur, it is usually due to an error in the choice of the anæsthetic. Dr. Hewitt states that not a single death has yet occurred under nitrous oxide gas when administered in combination with oxygen.

From these facts it becomes obvious that whenever possible nitrous oxide should be employed, and in other cases, unless there be some special reason to the contrary, ether should be given a preference over chloroform. The dangers of the latter drug, however, can be considerably lessened by inducing anæsthesia by means of gas and ether, or ethyl chloride and ether, and then continuing with chloroform after the excitement stage is passed, for this is the stage in which a large proportion of the deaths occur.

Chloroform is much safer in **Tropical Climates** than in this country, and it is better suited than ether

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[1] Turnbull, "Artificial Anæsthesia," p. 443.

for use in those places, on account of the low boiling point of the latter drug, 95° F., which is frequently exceeded by the external temperature. The greater safety of chloroform in the Tropics is due in part to the fact that much of the drug evaporates, and never reaches the patient at all; also to the fact that elimination of the drug from the blood takes place more rapidly when the atmosphere is hot and dry, than when the opposite conditions exist. Another factor, which seems to have been overlooked by most writers on the subject, is the freer ventilation of the operating theatre that is naturally arranged in places where high temperatures prevail. My own experience in the Tropics, however, led me to the conclusion that a mixture of chloroform and ether was preferable to plain chloroform even there. The proportionate amount of ether that is added to the chloroform must depend largely upon the temperature. Thus, I found that when the temperature was below 90° F. a satisfactory anæsthesia could be obtained with a mixture of equal parts of the two drugs (C_1E_1); with a temperature between 90° and 95°, a mixture of two parts of chloroform with one of ether (C_2E_1) gave the best results; but when the temperature was above 95° F., a perfect anæsthesia could only be obtained by employing plain chloroform. In my cases, the patients were all men, and the apparatus employed was a Skinner's mask with a double layer of flannel. With a Rendle's mask, the proportion of ether in the mixture could doubtless have been greater. Also, the majority of my cases were performed at an altitude of more than 4,500 feet above sea-level. On an average, I found that the induction stage occupied the same length of time as in this country, but about twice as much chloroform was required.

Whatever drug be chosen an alternative one must always be ready at hand, in case anything should occur during the administration to make a change advisable or necessary.

The anæsthetic for use in cases presenting no special features of their own should, of course, be the safest; and this is undoubtedly nitrous oxide, with either air or oxygen. Unfortunately, this drug is only applicable to a certain number of cases, so for prolonged operations we have to choose between ether and chloroform, or mixtures containing chloroform. According to most authorities in England, ether is the safest of these: it may either be employed by itself, or as a part of a sequence, such as the gas—ether sequence; the ethyl chloride—ether sequence; or the C.E.—ether sequence.

Ether has many advantages over chloroform, the chief of which are:—

(1) The breathing is much deeper and is usually distinctly audible, so that the administrator never has to watch carefully to see whether the patient is breathing or not, or whether any change has occurred.

(2) Ether is a circulatory as well as a respiratory stimulant.

(3) Though the recumbent position is preferable, it need not be insisted upon during ether administration.

(4) Reflex troubles are less likely to arise during the administration of ether than during that of chloroform; and if they do occur under ether they are not so dangerous to life as when they occur under chloroform.

(5) A temporary overdose of ether is not nearly so dangerous as an overdose of chloroform.

(6) Secondary hæmorrhage is less likely to occur after ether than after chloroform.

On the other hand, chloroform also has its advantages ; but they are mainly on the side of convenience, whereas the advantages of ether are on the side of safety. The main advantages of chloroform over ether are :—

(1) It is more portable, and no special apparatus is necessary during the operation.

(2) There is less congestion, and consequently, less bleeding.

(3) An inexperienced administrator may entirely fail to induce anæsthesia with ether ; while anybody can do so with chloroform.

(4) The respiratory movements are generally less under chloroform than under ether, which is of importance in some abdominal operations.

(5) In some cases the slight deprivation of air, which is necessary when ether is employed, may be detrimental to the patient.

(6) Chloroform is rather less liable to cause after-sickness.

In addition to these points there are many other advantages on both sides in certain special cases which will be considered presently; and though the list of exceptions may seem to be a long one, yet in reality the majority of cases can be, and should be, anæsthetised with ether in this country. In hot climates, apart from other reasons, the absolute impossibility of keeping an india-rubber inhaler in order may necessitate the use of chloroform. After due consideration of the above-mentioned points, the choice of an anæsthetic will be influenced by the condition of the patient and the nature of the operation. This will now be considered in detail.

I.—Influence of the Condition of the Patient on the Choice of an Anæsthetic.

A.—Age.

Between the ages of about 16 and 60 years the choice of the anæsthetic depends upon other influences, and in this connection it may be mentioned that it is not the *actual* age, but the *apparent* age that is of importance.

Infants and **children** under 6 years of age do not take nitrous oxide gas well, even with the addition of oxygen. Cyanosis and jactitation are almost certain to occur, and probably opisthotonos also. The resulting anæsthesia is short and accompanied by much movement and noise. Children between the ages of 6 and 10 years take the gas fairly well if plenty of oxygen be given with it, but they will only give a few seconds anæsthesia after the face-piece has been removed, and will probably be noisy. Consequently, for short operations such as tooth extraction or the removal of adenoids, it is usually better to administer ethyl chloride: but gas may be used if desired as a preliminary to ether for prolonged operations. After the age of about 10 or 12 years, children give a good anæsthesia with nitrous oxide and oxygen, though they will not remain under so long as adults. Fortunately, while childhood is the least satisfactory period of life for nitrous oxide anæsthesia, it is the most satisfactory for ethyl chloride. With a single dose of this drug a quiet anæsthesia, lasting on an average one and a half minutes, can usually be counted upon, and the dose may be repeated if more time be required.

Ether by itself is not as a rule a good anæsthetic for children under 14 years of age, though there are many exceptions to this statement. When used, it must be administered from an open mask or cone, and not from a closed inhaler with a bag; for if so used it will cause excessive secretion of mucus, and cyanosis; and may be followed by severe bronchial or pulmonary complications. On the other hand, chloroform is by no means the safe anæsthetic for children that is sometimes stated. A large number of deaths have occurred, and do still occur frequently, during the administration of chloroform to young children. Another strong objection to the use of chloroform for young subjects is their special liability to pass into a state of *false anæsthesia*—practically a state of sleep—in which the child lies perfectly quiet and flaccid, with pin-point pupils, immobile eyes, and very shallow respiration. Once these little patients get into this condition, it is not always an easy matter to bring them out of it, unless the surgeon commences his incision, when serious reflex troubles may occur. The best way to avoid this, and in my opinion, the best way to anæsthetize all children under 10 or 12 years of age, is to employ a mixture of chloroform and ether on lint or some form of open mask. The strength of the mixture may be 1 part of chloroform to 2 parts of ether (C_1E_2) for young infants and feeble children, and equal parts of chloroform and ether (C_1E_1) for older and more robust children. The mixture may, if preferred, be preceded by a few drops of plain chloroform, so as to pass over the initial stages of discomfort more quickly. If there be a great deal of screaming and fighting, chloroform should be entirely avoided during induction, and ether poured freely on to the mask (still an open one) until the patient becomes quiet, when the C.E. mixture should be used for the remainder of the time. Induction in this way by means of ether may seem rather cruel, but it is better than running the risk of a death from an overdose of chloroform, which is liable to result from a large quantity of the vapour being absorbed during the deep breathing which follows the struggling, and being carried direct to the heart which is exhausted by the fighting.

It will frequently be found that young children require comparatively a large amount of the drug to *induce* surgical anæsthesia; but special care is necessary, because deep narcosis sometimes supervenes with remarkable suddenness, and an overdose may easily be administered. Once under, they only need very little to *maintain* the anæsthesia; and a weaker mixture, or even ether by itself, is often found desirable, if not necessary.

During operations upon tuberculous joints, children are particularly apt to show signs of severe shock, and the breathing not infrequently ceases as a result of chloroformization. In these cases, deep anæsthesia should be obtained by means of a mixture of chloroform and ether, until the first incision has been made; after which, very little more of the anæsthetic should be given, and either a weaker mixture or plain ether should be employed during the remainder of the operation.

The risk of bronchial complications following ether anæsthesia in children must be very small, when the ether is properly administered; for I have frequently enquired about after-effects at the Hospital for Sick Children, Great Ormond Street, but have never yet heard of a single one of my cases there having suffered from any respiratory complications after ether; though I use ether in one form or another during at least some part of practically every case there.

Dr. Hewitt recommends, for children of 2 or 3 years of age, the use of the C.E. mixture on an open inhaler to induce anæsthesia, which is afterwards maintained by ether in a Clover's portable regulating inhaler; but closed inhalers are better avoided with children.

Elderly patients, also, do not take ether from a closed inhaler well; or, if they take it satisfactorily at the time, there is danger of bronchitis or pneumonia afterwards. If, for any reason, ether be chosen for one of these subjects, it is better to induce anæsthesia with the C.E. mixture than with either nitrous oxide gas or ethyl chloride; and more air must be admitted than is done with middle-aged patients. Also, if the operation be a long one, the ether should be replaced by chloroform after half an hour or so. Generally, the best plan for patients over 65 or 70 years of age, is to employ the C.E. mixture throughout in a Rendle's mask or open inhaler.

Elderly subjects take nitrous oxide gas well if combined with oxygen, for short operations; but it is not advisable to use ethyl chloride for these patients.

B.—Sex and Muscular Development.

Sex, *per se*, makes no difference to the way in which an anæsthetic is taken, but *hysteria* is more likely to be present in women than in men, and adds to the danger of chloroform. It also causes a shorter and less satisfactory anæsthesia with nitrous oxide. For prolonged operations, the gas—ether, or the ethyl chloride—ether sequence is the safest and best. On the other hand, men are more likely to indulge in excesses of *alcohol* and *tobacco*, which necessitate a large amount of the anæsthetic being employed, and increase the liability to spasm and coughing in the early stages, during which time chloroform is specially dangerous. These alcoholic subjects take all anæsthetics badly, but ethyl chloride and ether is the safest and most generally satisfactory method to employ. Ethyl chloride by itself for dental operations will not be found satisfactory.

The only other effect that sex makes on the choice of an anæsthetic is due to the difference in the muscular development of men and women. The excitement stage is more prolonged and more marked in the case of powerful men than in that of delicate women; and consequently, interference with respiration due to muscular spasm is more liable to occur with the former class of patients. These should therefore be anæsthetized with ether rather than with chloroform, if possible; at least, until the excitement stage has been passed. Delicate or *anæmic* patients take most anæsthetics well, provided that plenty of air or oxygen be allowed. *Very fat people*, and especially those with short, thick necks, are not, as a rule, good subjects for ether; for the congestion due to this drug causes obstruction to their breathing; and even with chloroform, it may be hard work to keep their jaw and tongue from being drawn back. Other things being equal, they will give the best results with the C.E. mixture. Ethyl chloride is not suitable for strong, muscular men, except as a preliminary to ether. Children, women and delicate men take it well; but in a muscular subject, movements and struggling are usually excessive.

In cases in which there is marked *collapse,* very little anæsthetic is necessary; and the lightest possible narcosis should be maintained by means of the C.E. mixture, which may be used throughout, or may be followed by ether in a Rendle's mask; for the free admission of air must not be interfered with by a closed inhaler. Nitrous oxide gas is unsuitable in such cases. If the collapse be very severe, a saline infusion containing brandy may be administered into the axilla as soon as the patient is anæsthetized. When the radial pulse cannot be felt at all, and the extremities are cold, it is not advisable to attempt the administration.

C.—Pregnancy.

In women who are prone to abort, and in others after the sixth month, it is advisable to postpone the operation, if possible, until after the confinement. But, if this cannot be done, the best anæsthetic to employ is ether, preceded by ethyl chloride or the C.E. mixture; special care being taken to guard against cyanosis and after-sickness. Nitrous oxide gas may be administered in combination with oxygen for dental operations, but jactitations must not be permitted to occur.

Lactation as a rule is unaffected by anæsthetics.

D.—Disorders of the Heart and Vessels.

The *pulse* should always be felt before commencing the administration of an anæsthetic, and its frequency noted. Otherwise great frequency or slowness, if only discovered during narcosis, may be wrongly ascribed to the effects of the drug; whereas it may be the normal rate for the individual under observation.

Mitral Incompetence.—The mere existence of a mitral systolic murmur, without symptoms, does not necessitate any deviation from the ordinary methods of giving an anæsthetic, except that greater care should be taken during the administration to avoid all unnecessary asphyxiation. Ether is born well; but it is better, except in quite slight cases, to induce anæsthesia by means of the C.E. mixture or ethyl chloride rather than with nitrous oxide gas.

If, however, there be signs of *cardiac failure*, such as cyanosis, cough, dyspnœa, œdema of the bases of the lungs, or general anasarca, great care is necessary, and certain special precautions must be adopted. Such cases should not be undertaken by the inexperienced, as considerable judgment is required. Gas and ether must be avoided. If there be no great urgency for the operation, it should be postponed until compensation has been brought about by a course of digitalis or strophanthus, and nux vomica, together with other suitable treatment. The best anæsthetic for most of these cases is a weak C.E. mixture, which should be given in a Rendle's mask, and freely diluted with air; but, with the failure of compensation, there will probably be orthopnœa, which adds considerably to the risk of sudden syncope during the administration of chloroform or a mixture containing it. Hence, ether may be absolutely essential, at least during the later stages of the administration; but, if so, it must be given in the Rendle's mask or on a Skinner's frame, and not in a closed inhaler. The anæsthesia should not be commenced until the surgeon is ready, and should be maintained in the lightest possible stage. As soon as consciousness is lost, it may be well to inject 5 minims of liquor strychninæ hydrochloratis hypodermically; and it may be necessary to lower the patient into the recumbent posture during the operation.

Mitral Stenosis.—In these cases, the best plan is to give the C.E. mixture throughout. Dr. Hewitt[1] quotes three cases of patients suffering from mitral stenosis, who were successfully anæsthetized with the A.C.E. mixture; though in one of the cases, ether had been previously tried with a nearly fatal result. Dr. McCardie also mentions a case[2] of "Spasmodic closure of the larynx during the administration of ether, in a patient with mitral stenosis," who afterwards bore the A.C.E. mixture well; and another case of mitral stenosis in which he gave the C.E. mixture in a Clover's inhaler without the bag, and had no trouble. The ill-effects of ether in these cases appear to be due

[1] Hewitt's "Anæsthetics," p. 395.

[2] *British Medical Journal*, January 20, 1900, p. 138.

to the fact that it increases the frequency of the heart's action to such an extent that a sufficient quantity of blood cannot pass through the stenosed orifice during the shortened diastole.

Aortic Valvular Disease. — Syncope is liable to occur in the subjects of aortic disease during the induction period if struggling take place. The C.E. mixture or chloroform should be employed, and it must be given very gradually, and with plenty of air. Ether, by the semi-open method, may be substituted for the chloroform or C.E. after the patient is under, if desired. The recumbent posture must be insisted upon. These cases are also liable to an attack of syncope as they are coming round after the operation: great care must therefore be taken to prevent them from sitting up, or even raising themselves at all from their bed, until the effects of the anæsthetic have entirely passed off.

For short operations, nitrous oxide with oxygen may be given, provided the cardiac lesion be not very advanced; but more oxygen than usual should be added.

Children with **Congenital Heart Disease** should be anæsthetized very gradually with a mixture of chloroform and ether on a Skinner's mask, great care being taken to prevent any intercurrent asphyxia. In the case of children, this is the only method admissible; but adults suffering from this condition may sometimes be given nitrous oxide gas with oxygen for short dental operations, a larger proportion than usual of oxygen being admitted. For longer operations, the C.E. mixture should be administered in a Rendle's mask. The head should be kept low, and cyanosis must be strenuously avoided. For this reason, a small dental prop should be inserted between the teeth, and a bottle of oxygen ought to be ready at hand, and turned on at once if any blueness manifests itself; or as a precautionary measure, oxygen might well be administered in conjunction with the anæsthetic throughout. The lightest anæsthesia compatible with the requirements of the surgeon should be maintained.

Patients with **Fatty Hearts** likewise take gas and oxygen well; and for prolonged operations, the C.E. mixture, followed by ether in a Rendle's mask or Ormsby's inhaler, according to the severity of the condition, will be found to be the most satisfactory.

DISEASES OF THE VESSELS will sometimes cause the anæsthetist as much anxiety as disease of the heart itself. Patients suffering from marked *atheroma* should not be given ether. Dr. Hewitt quotes a case of death which took place at the London Hospital from cerebral hæmorrhage, due to the anæsthetization of an atheromatous subject with ether; and my brother left a brief note of a similar case which occurred at the Charing Cross Hospital. The safest plan is to employ chloroform on a Skinner's mask, and to induce anæsthesia slowly and gradually, so as to avoid straining and struggling as far as possible. The same remarks apply to cases of *aneurysm*, if at all large. Nitrous oxide gas with oxygen may sometimes be used for dental operations with care. I have anæsthetized one bad case of this kind with gas and oxygen for a dental operation. The patient was a medical man, aged 50, who had a large aortic aneurysm, and who had also developed the morphia habit: the induction, anæsthesia and recovery were all perfectly normal and uneventful.

E.—Disorders of the Respiratory System.

The difficulties that may arise from certain conditions of the teeth, and their treatment, are considered elsewhere.

Large Tonsils and Adenoids frequently cause trouble during anæsthesia. If any asphyxiation be permitted in these cases, the growths will increase in size, and obstruct the breathing considerably. The C.E. mixture is the best anæsthetic to use in such cases for prolonged operations; and ethyl chloride for short ones: if nitrous oxide and oxygen be employed, more oxygen than usual will be required. In any case where there is obstruction to free nasal breathing, a small dental prop should be placed between the teeth before commencing to administer an anæsthetic, so as to ensure a free entry of air through the mouth.

Goitre, Large Glands, Aneurysm or other Tumours pressing on the Trachea, and causing Dyspnœa: Tracheal Stenosis, Œdema of the Larynx, Diphtheria, &c. The anæsthetization of patients in any of these conditions is a serious matter. Nitrous oxide gas is highly dangerous in such cases, as it increases the dyspnœa; but sometimes nitrous oxide with oxygen is permissible, provided the obstruction be only slight. Ethyl chloride should be avoided. This is the class of case in which nearly all of the fatalities under nitrous oxide gas, and many of those under ethyl chloride, have occurred. Ether likewise is liable to increase the dyspnœa to a dangerous extent. Hence, we are only left with the C.E. mixture and chloroform to choose from; and either of these may be used in moderately severe cases, but chloroform alone should be employed if considerable obstruction exist. The depth of anæsthesia that is safe depends upon the degree of obstruction: the greater the obstruction, the lighter must be the anæsthesia.

In **Asthma**, if the inhalation be for the relief of an attack, a few whiffs of chloroform may be given on a handkerchief at intervals when necessary; another plan is to anæsthetize the patient to about the second degree with chloroform, and then leave him to sleep. Mr. Tyrrell[1] has pointed out that ether also relieves the asthmatic attacks in some cases.

If, however, the anæsthetic be given for surgical purposes to an asthmatic subject, it is best to commence with chloroform or the C.E. mixture, and to change to ether, if possible, after the patient is under. Nitrous oxide and oxygen may be given to asthmatics for dental operations, but trouble is liable to occur during recovery.

Bronchitis. — Patients who are the subjects of chronic bronchitis will take ether well for a time, but it should not be persisted in for more than about twenty minutes or half an hour; and care must be taken to allow the free admission of air. During a subacute attack ether cannot be employed; the C.E. mixture in a Rendle's mask should then be used; and if this be not well borne, chloroform on an open

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[1] *Transactions of the Society of Anæsthetists*, 1898.

inhaler must be substituted. Nitrous oxide gas must only be administered when the condition is chronic, and it should always be combined with oxygen.

In **Emphysema**, special care is required. On the one hand, ether would probably cause coughing; and on the other hand, there is danger with chloroform lest *accumulation* should occur from the feebleness of the expirations. On the whole, the best results are given by chloroform, or the C.E. mixture; a free dilution of the vapour with air being very important. Nitrous oxide with oxygen may be administered during short operations.

Pneumonia, Pleurisy, Empyema, and Œdema of the Lungs.—In all these cases, the administration of an anæsthetic is attended by grave risk. Chloroform or one of its mixtures should be employed, and only a light anæsthesia maintained throughout: ether is liable to increase the symptoms. Sometimes, however, it may be necessary to substitute ether by the open method after the patient is under. The breathing and the colour require careful watching, as either asphyxia or syncope may occur. When the patient only has one lung to breathe with, he must not be turned on to his healthy side; else the movements of that side of his chest will be hampered, and asphyxiation is bound to result.

Dr. Dudley Buxton[1] advises the use of ether combined with oxygen in cases of lung and pleural disease.

Patients suffering from **Phthisis** are best put under with chloroform or the C.E. mixture; which may be replaced by ether, if it can be borne, later. If there

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[1] Buxton's "Anæsthetics," p. 32.

be any hæmoptysis, or history of hæmoptysis, ether should be avoided. Nitrous oxide may be given if there be not much cough. The inhalers, face-pieces and other instruments used *must be thoroughly disinfected* after anæsthetizing a patient suffering from phthisis.

F.—Disorders of the Abdominal Viscera.[1]

Abdominal Distension, due to peritonitis, intestinal obstruction, distended bladder, pregnancy, ascites, or tumours of the spleen, liver, kidneys, or ovaries, causes interference with the normal abdominal respiration, displacement of the heart and consequent interference with its action. The greatest possible care is necessary in anæsthetizing these cases to prevent the occurrence of syncope or of an increase of the respiratory difficulty. Anæsthesia should be induced by chloroform or the C.E. mixture, given very gradually; and it will probably be necessary to continue with ether in a semi-open inhaler. If the distension be due to fluid this should not be allowed to escape too rapidly; and if the pulse becomes irregular, the escape should be entirely stopped for a minute or two until the heart has recovered. In the case of a distended bladder, it should, of course, be emptied before the operation, either naturally or with the aid of a catheter, unless a very tight stricture renders this impossible.

As a rule these patients cannot breathe in the recumbent position, and must, therefore, be anæsthetized sitting almost upright, and no attempt must

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[1] See also p. 96.

be made to alter this position after consciousness has been abolished until the pressure has been relieved. The Trendelenburg posture is generally absolutely impossible, as it throws the whole weight of the abdominal contents on to the diaphragm and prevents respiration from taking place at all.

There is another special danger in anæsthetizing cases of **intestinal obstruction**: the contents of the bowel may flow up into the mouth without any visible effort of vomiting. Unless the anæsthetist be prepared for this, the vomit may be inhaled, and drown the patient before any suspicion has been aroused. In all such cases the head should be kept well over to one side, and the mouth should be kept open with a dental prop, so that any fluid that regurgitates into the mouth may flow freely away. In these cases a light anæsthesia should be maintained throughout, the lid-reflex being kept always present and not even allowed to become sluggish. After the operation is over the patient must be placed on his side in bed with a pillow along his back, and with his legs bent up to prevent his rolling over.

G.—Renal Disease.[1]

There has been considerable difference of opinion on the subject of the choice between ether and chloroform for patients suffering from renal disease. Both drugs have been stated to have caused albuminuria, and chloroform seems more liable than ether to initiate albuminuria where it did not previously exist; while

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[1] See also p. 98.

ether is said to be more prone than chloroform to cause an increase of pre-existing albuminuria, as well as hæmaturia and suppression. Most anæsthetists prefer, therefore, to give chloroform if the patient is suffering from severe kidney disease; but if the disease be not advanced they do not depart from the ordinary indications. Dr. Rodman, in the *Therapeutic Gazette*, quotes a case of death from total suppression of urine on the fourth day after removal of the breast under ether, and one on the sixth day from the same cause after a laparotomy under the same drug. An autopsy was performed in the second case, and the kidneys were found to be swollen and red, and weighing between 11 and 12 oz. each. Not a drop of urine was secreted for three days prior to the patient's death.

H.—Diabetes.

If possible a diabetic patient should undergo a thorough course of treatment prior to the operation, so as to diminish the amount of glycosuria as much as possible. Though rare, it must be remembered that the anæsthetic coma *may* pass directly on to diabetic coma and death. The C.E. mixture should be chosen and the least possible quantity of it must be administered.

I.—Disorders of the Brain and Nervous System.[1]

If an operation be required for a patient suffering from **Insanity**, gas and ether may be given; or the

[1] See also p. 99.

anæsthesia may be commenced with the C.E. mixture if a face-piece be resented. The administration of an anæsthetic to a patient who has a history of previous attacks of insanity may be followed by a fresh outbreak. *Epileptics* are liable to have a fit either in the early stages of anæsthesia, which will pass off as the narcosis deepens, or one may occur during recovery, which is more common. No special procedure is indicated in such cases beyond the placing of a dental prop between the teeth to save the tongue from injury.

Tumours, Diseases or Injuries, old or recent, of the brain or spinal cord causing *pressure,* may hamper either the breathing or the heart's action. The choice of the anæsthetic must depend on the exact condition of the patient : the surgeon usually prefers chloroform, but ether may be essential for the safety of the patient. It should be administered by the open or semi-open method. Many of these cases are more or less drowsy before the commencement of the administration, and then only very little of the anæsthetic is required, an analgesic rather than a true anæsthetic state being aimed at. These conditions will be referred to again in considering the choice of anæsthetics during operations on the brain and spinal cord in the next section.

2.—Influence of the Nature of the Operation on the Choice of an Anæsthetic.

Sometimes in this section we shall find that the nature of the operation necessitates the use of an anæsthetic, or a procedure, which is opposed to what was stated in the preceding section. For example, a patient in such a condition that ether would be indicated may nevertheless require chloroform to be administered through a Junker's inhaler and mouth-tube, for a prolonged operation upon the mouth. In these instances we must compromise as far as possible, for the most perfect anæsthesia would obviously be useless if the position of the inhaler, or other cause, prevent the performance of the operation.

A.—Length of Time Required.

As a rule, neither chloroform nor ether will be required for an operation lasting less than five minutes. If only a few seconds be required, plain nitrous oxide gas will suffice: this will give, on an average, an anæsthesia of about half a minute. For operations lasting a little longer—from 30 to 45 seconds—the combination of nitrous oxide gas with oxygen is the most satisfactory. But, if the operation be likely to last one minute or longer, the choice must depend upon the position of the operation. Thus, if it be within the mouth, nitrous oxide with oxygen may be given, and as much as possible of the operation performed; and when signs of returning consciousness appear, the inhaler may be re-applied, and deep narcosis again produced. The operation may then be completed; or, if necessary, a third application can be made. This interference with the operation, however, is rather troublesome; and, therefore, if there be no nasal obstruction, it is better to administer nitrous oxide gas by the nasal method, so that the operator can continue his work while the gas is being given. Even the nose-piece may be in the way of the operator sometimes during the extraction of the front teeth in the upper jaw; so, in these cases, ethyl chloride is the best anæsthetic to employ, provided the patient be a good subject for it.

When the operation is not within or near the mouth, nitrous oxide gas, with air or oxygen, can be given continuously; or ethyl chloride may be administered with frequent breaths of air, about 2 cc. of the drug being poured into the inhaler every minute: the quantity and frequency of the additions must, of course, depend on the results obtained.

For prolonged operations, ethyl chloride is not very satisfactory; and the same may be said of nitrous oxide and oxygen. The choice, therefore, falls on either chloroform, ether, or a mixture, and must depend upon other factors. Ether, however, should not usually be continued for more than an hour.

B.—Operations within or near the Mouth.

These are very important and interesting, and often very difficult. Ordinary **Dental Operations** should be performed under nitrous oxide gas, alone, or with air or oxygen, as described in Chapter VI. If a large number of teeth are to be extracted at the same sitting, ethyl chloride may be used, or nitrous oxide gas administered continuously by the nasal method; or gas and oxygen may be given in the ordinary way, and re-applied as often as is necessary. Gas and ether is sometimes employed in these cases, but the after-effects are more severe. Young children do not take gas very satisfactorily, whereas they take ethyl chloride remarkably well; so that this drug should be used for young subjects whenever more than one or two easy teeth are to be extracted.

Very prolonged dental operations must be treated in the same way as general surgical cases. If chloroform or one of its mixtures be used, the patient must be fully prepared as for any other operation, and must be anæsthetized in the recumbent position; with any other anæsthetic, he may be seated in a chair, with a support for the head, which latter must be in a straight line with the body. A dental prop of suitable size should always be inserted beforehand (unless ether or chloroform is to be used), and care should be taken to fit the prop firmly between sound teeth, so as to prevent it from slipping.

For the **Removal of Tonsils and Adenoids**,[1] both anæsthetists and surgeons differ considerably in their choice of anæsthetic. Amongst those in most frequent use may be mentioned :—

Nitrous oxide gas, with air or oxygen
Ethyl chloride ;
Ether ;
Chloroform ;
The C.E. mixture ;
Ether, followed by chloroform ;
Ether, preceded by either nitrous oxide gas, ethyl chloride, or the C.E. mixture.

There are also differences of opinion as to which is the best position of the patient ; the most frequently employed being :—

(1) The dorsal position, with the head in the mid-line ;

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[1] See also p. 71.

(2) The dorsal position, with the head turned to one side;

(3) The dorsal position, with the head extended over the end of the table;

(4) The lateral position; and

(5) The sitting position.

Each of these positions, and each of the methods of producing anæsthesia, has its advantages and its disadvantages.

Nitrous oxide gas does not usually give sufficient time for the operation to be performed thoroughly, especially when the patient is a child. It also causes congestion and consequently profuse bleeding; and children may exhibit inconvenient movement or rigidity, cyanosis and noise. On the other hand, it is the safest anæsthetic, and may be administered while the patient is sitting up or lying down; the recovery is quick; there are practically no after-effects; and if combined with oxygen, many of the disadvantages of the gas are removed.

Chloroform should not be administered if the surgeon requires the patient to be in the sitting position; more time is required for inducing anæsthesia with chloroform; recovery is slower, and the after-effects are more marked: but the anæsthesia is longer, so that the operation can be performed more deliberately and thoroughly; and bleeding is much less than when nitrous oxide gas is used. There is also perfect flaccidity of the muscles, and no noise. If chloroform is to be administered, the patient must be thoroughly prepared beforehand. The most important point, however, is that the death-rate under chloroform during the adenoid operation is alarmingly high. The danger can be greatly lessened by substituting the C.E. mixture for the chloroform, and this is not so unsafe, even in the sitting posture.

Ethyl chloride answers admirably for these cases in hospital practice, where several cases have to be done successively. It gives an anæsthesia lasting about twice or three times as long as nitrous oxide; while it is much quicker than chloroform, and the after-effects are considerably less. An objection to its use in private cases, is that the patient, if a child, recovers

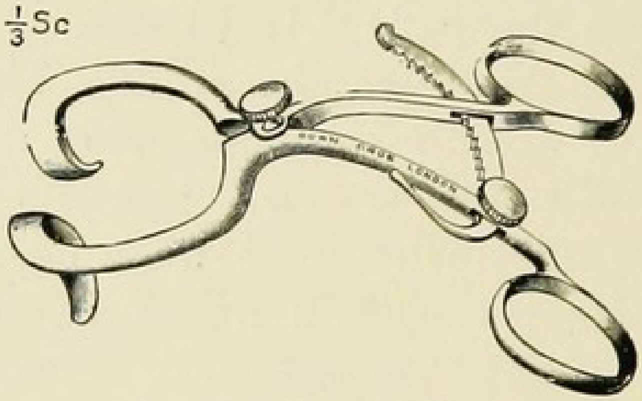

FIG. 2.—Doyen's Gag.

and begins to cry before there has been time to let the parents know that the operation is completed; and therefore they presume that the crying means that the child is feeling the pain of the operation. If ethyl chloride or nitrous oxide be chosen, a gag or mouth-prop must be inserted between the teeth before the administration is commenced. A convenient gag for this purpose is shown in fig. 2, and bears the name of Doyen. It is so shaped that, when the blades are placed between the central teeth, both tonsils can be reached without moving the gag, and the handles are bent in such a way as to fit round the cheek beneath the face-piece of the inhaler.

Ether followed by chloroform is safer than chloroform throughout. Ether preceded by nitrous oxide gas, ethyl chloride or the C.E. mixture, is very good; but there is more hæmorrhage than when either chloroform or the C.E. mixture is used, and the after-effects are more severe than when nitrous oxide or ethyl chloride is employed.

Next, as regards posture, the *Dorsal position with the head in the mid-line* is convenient for the surgeon; but the throat becomes full of blood, which might possibly be inhaled; though this is a much over-estimated danger. The blood should be sponged out as quickly as possible, but the sponges get in the surgeon's way. This may be avoided to some extent by turning the patient's head to one side. But, if the operation can be performed in this position, it is much better to turn the patient completely on his side, so that all the blood can run freely out of the mouth.

The Dorsal position with the head extended over the end of the table is bad from the point of view of the anæsthetist. It suits the surgeon, because the blood collects in the naso-pharynx, and runs out through the nose and mouth, instead of being inhaled. But this position generally results in making a terrible mess of the room, and everyone in it. Hæmorrhage is more profuse; while coughing and swallowing in such a position are almost impossible. Also, the patient frequently has severe pain in the back of the neck for several days afterwards.

The *Sitting position* is very popular with some surgeons; but if this position be chosen, chloroform should be avoided, and even the C.E. mixture is not advisable. The head must not be tilted backwards; and as soon as the operation is completed, the whole body should be thrown well forwards.

Each of these positions and modes of anæsthetising the patient has its supporters; and it is, therefore, not easy to lay down definite rules on the subject. But, from the anæsthetist's standpoint, it is better to have the patient lying down, and to administer ethyl chloride if there be a large number of cases to be done in succession in hospital; or the C.E. mixture if there be only a single case. When ethyl chloride is chosen, the preparation of the patient need not be so severe. The patient being placed in the required position, either sitting or lying down, a dental prop should be inserted between the teeth: this is replaced by a Mason's or Fergusson's gag after the face-piece is removed; or, if preferred, a Doyen's gag may be used from the commencement. The ethyl chloride is then sprayed into the inhaler, and the latter quickly applied to the patient's face. When anæsthesia is produced, the gag is opened to the required extent, and the inhaler removed. During the operation, the anæsthetist must prevent any growth or blood from entering the air-passages either by position or by sponging, and in about two minutes consciousness will return, and the patient can be removed if necessary.

The best plan, however, when there is only one patient to be considered, is to use a mixture of chloroform and ether. The strength of the mixture, and the actual mode of administration, must depend upon the age and general condition of the patient, and will be discussed in the chapter dealing with these mixtures.

The patient should be placed upon the table, and be allowed to assume whatever position is most comfortable to him; and the C.E. mixture administered until *full surgical anæsthesia* has been produced. The inhaler is then laid aside, and the patient moved into the position in which the operation is to be performed. The necessary sterilized towels may then be deliberately arranged, and a gag inserted. There need be no hurry about these preliminaries, as the operation should not be commenced until the reflexes are returning. After the completion of the operation, the patient should be replaced in bed in the lateral, or semi-prone position, with the legs drawn up, and a pillow along the back to prevent rolling over. The gag should be closed, but left in position for a few minutes in case of necessity. In this way all blood, &c., will escape freely from the mouth. The operation should not be commenced during deep anæsthesia; but the results will be better if this state has once been obtained, and allowed to pass off again, than if the operation be commenced as soon as the patient reaches the second stage; for there will be more complete relaxation of muscles; and reflex disturbances of the heart or respiration are less common, if indeed they occur at all; which, however, they may do if the operation be commenced earlier. With this method, moreover, there is usually not the slightest mess.

For most **Rhinological Operations,** the surgeon prefers to have his patient sitting up, and as a rule, the narcosis must be produced by chloroform. This throws a great responsibility on the anæsthetist, but it can be done if the respiration be kept unembarrassed.

The sitting position can be rendered safer by spraying the part to be operated upon with a dilute solution of cocaine, so that the chloroform anæsthesia need not be so profound. The same remarks apply to operations for the removal of **Intra-laryngeal Growths,** or even for a **Laryngological Examination** in children; but these cases should not be attempted by anyone who has not had a large experience in the administration of anæsthetics.

The great majority of operations on the **Jaws, Tongue,** or inside of the cheek, can be performed

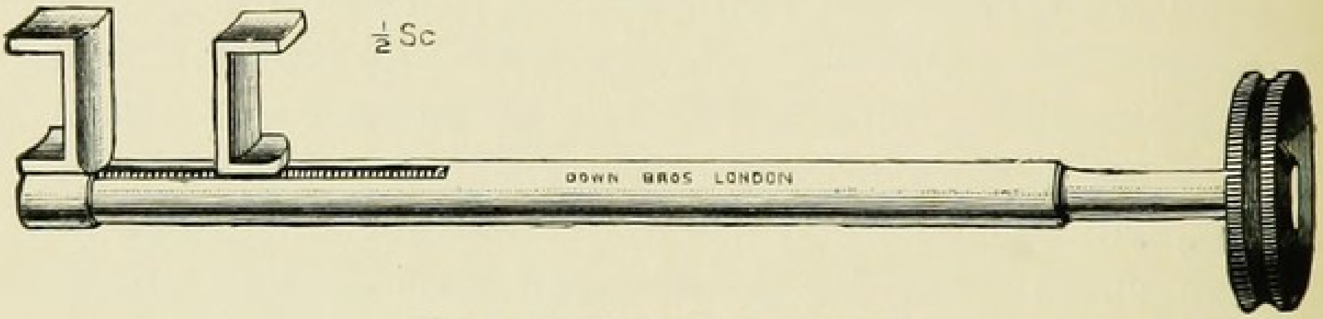

Fig. 3.—Hewitt's Screw Gag.

with the patient lying on the side; and if so, very little sponging of the throat is necessary, since the blood can run directly out of the mouth. Also, a very deep anæsthesia is not usually required in these cases. If possible, anæsthesia should be induced with ethyl chloride and ether, or gas and ether, and afterwards maintained between the second and third degrees by means of chloroform pumped through a Junker's apparatus with a mouth-tube attached. When the patient's head is in this position, the ordinary Mason's or Fergusson's gag is liable to get in the surgeon's way; hence, Dr. Hewitt has designed the gag shown in fig. 3, which lies beneath the lower cheek, and is opened by means of the screw which projects above the patient's head. Sometimes a preliminary tracheotomy is performed before very extensive mouth operations, and a large sponge or other plug placed in the pharynx. This certainly renders the anæsthetist's task much easier, for he then has simply to give his chloroform through the tracheotomy wound, without any fear of his patient being choked with blood. But such a procedure should not be necessary if there are good assistants helping at the operation.

As regards the operation for **Cleft Palate,** there are certain important points upon which the anæsthetist is unfortunately seldom consulted. One of these is the *age* at which the operation should be performed. In this matter, I differ very slightly from Mr. Arbuthnot Lane's opinion: he likes to operate on the day of birth if possible; and if he cannot get the child on that day, he considers that every day's delay makes it worse for the child. This may be correct from the surgeon's point of view; but, having administered the anæsthetic during some hundreds of cleft palate operations at the Hospital for Sick Children, Great Ormond Street, and elsewhere, I have come to the conclusion that the first or second day of life is not the best time from the anæsthetist's point of view. But once the infant has reached the age of one week, the sooner the operation is performed the better. Infants from a week to a month old take the anæsthetic excellently, if properly given, and there is hardly any bleeding. The child need not be starved beforehand, and it may be given milk as soon as it will drink it after the operation, without the slightest fear of sickness. Induction is usually quiet, and is never attended by that boisterous screaming and fighting which older children indulge in, and which sometimes results in death from a sudden overdose of the vapour being absorbed. If the operation be postponed until after the teeth have come through, there is more bleeding, and there is less room in the mouth : the child is usually ill-developed, and has to be starved before the operation, and is certain to be sick after it ; and it is these older children who most frequently give trouble during the anæsthesia. Another point on which the anæsthetist is seldom consulted is the kind of operation to be performed. Here again it is easier to give an anæsthetic for a Lane's operation than for the old method ; for it is quicker, and the hæmorrhage is much less ; in fact, once the flaps are thoroughly separated, there is usually no bleeding at all.

Supposing the patient to be a fairly healthy infant of from a week to a month old, I find that the best plan is to induce anæsthesia by means of a mixture of equal parts of chloroform and ether, sprinkled on a lint cone or Schimmelbusch's mask. The child should be allowed to assume what position it likes, and its movements should not be unnecessarily restrained. It will enjoy the sweet taste of the chloroform, and may be seen lapping in the vapour with its tongue, provided it be sufficiently dilute. The induction is sometimes long and tedious in young infants, but it is not advisable to hurry it ; and occasionally the transition to a deep anæsthesia takes place remarkably suddenly. When the full surgical degree has been reached, the gag should be inserted, and a stitch passed through the tongue, to keep it forward during the operation. This should never be omitted. The patient should lie flat on the back, with a small sand-bag under the neck, and the head slightly extended. For the remainder of the time, the anæsthetic must be delivered from a Junker's inhaler through a mouth-tube, which is held about 3 inches vertically above the mouth, and of course directed towards the cavity of the mouth. The Junker *may* contain chloroform, but a mixture of equal parts of chloroform and ether is better. If the breathing tends to become feeble, or if the lips get pale, more ether may be added, and a mixture of one part of chloroform with two parts of ether used: and if the condition does not appreciably

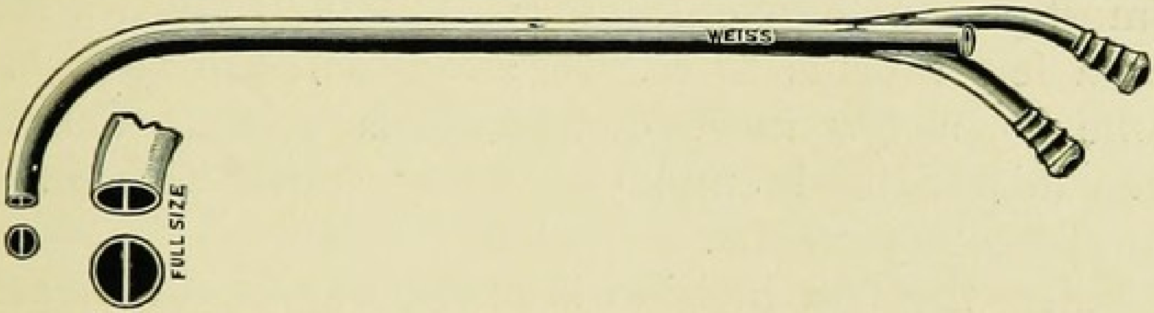

FIG. 4.—The Author's double tube for administering Oxygen with Chloroform during mouth operations.

improve with this more stimulating mixture, it must be thrown out and replaced by plain ether. If this be done, it may be necessary to warm the apparatus occasionally with the hand, or by dipping it into warm water, on account of the intense cold produced by the rapid evaporation of the ether. I have recently been employing oxygen with the chloroform vapour for some of the more feeble infants with most satisfactory results; and Messrs. Weiss have made a special form of tube for me for this purpose which is shown in fig. 4. It merely consists of a double metal tube of which the proximal ends diverge, so that one of them may be attached to the efferent rubber tube of the

Junker's apparatus, and the other to a tube connected with an oxygen cylinder. By this means, the supply of either chloroform vapour or oxygen can easily be controlled at will, and many patients may be satisfactorily anæsthetised in this way who would certainly cause grave anxiety if anæsthetised by the ordinary method. The extent to which the ball of the Junker is to be compressed depends upon the symptoms. A partial compression should be made with the thumb immediately before each inspiration. An even and satisfactory anæsthesia cannot be obtained if the ball be fully compressed several times till the child is almost poisoned by chloroform, and then given a rest for a few breaths to recover; and as soon as it has done so, a few more compressions given. I have seen this method employed many times with most unsatisfactory results.

Before the first incision is made, a sponge, attached either to a string or to a pair of Spencer Wells' forceps, should be placed in the back of the throat to prevent blood from passing down, but not inserted so firmly as to stop the breathing. This sponge may be left *in situ*, so long as it is not in the way of the surgeon; and at the same time, as much as possible of the blood must be removed by other small sponges before it has time to reach the back of the throat. After the flaps are separated, and the stitching is commenced, there will be no further need for the sponge at the back of the throat, but the moist surface of the wound should be occasionally wiped when necessary, care being taken not to injure the flaps. All unnecessary sponging should be avoided. Immediately the operation is completed, the gags and the stitch through the tongue should be removed, and the patient turned completely over on his face for a few minutes, so that any blood that may be in the mouth or behind the palate can flow out. This is far better than sponging it out.

The only remaining point to be mentioned is the depth of anæsthesia that should be maintained, and on this point various writers have differed. Personally, I think that full surgical anæsthesia, with loss of the vomiting and coughing reflexes, fixed eyeballs, no excessive lachrymation, and semi-dilated pupils, should be maintained throughout the whole operation; otherwise retching and vomiting, or even serious reflex cardiac or respiratory syncope, may occur. Cyanosis must never be permitted ;. and should it occur, it must be instantly remedied. Of course, with an inexpert operator, or with one who requires his patient to be in the Trendelenburg position, or in the dorsal position with the head extended over the end of the table, such a deep anæsthesia would be dangerous.

Before leaving the subject of mouth operations, one procedure requires special mention. If the cautery is to be used within or near the mouth, no ether must be administered within five minutes previously; otherwise an explosion may occur, and the result on the patient will be disastrous, if not fatal. A deep chloroform anæsthesia is necessary for such cases.

For operations on the **Lips** or **Cheeks**, the method of administration is practically the same as for operations within the mouth or nose.

C.—Operations on the Neck.

During operations on the neck, it is as important for the anæsthetist and his instruments to be thoroughly clean, as it is for the surgeon.

Tracheotomy[1] is best performed under chloroform, without the addition of any ether, as the latter may increase the dyspnœa if this be present, and under any circumstances it would increase the hæmorrhage.

A preliminary tracheotomy is sometimes performed before certain operations on the larynx or in the mouth, and the upper end of the trachea is then plugged, so as to prevent the blood from passing down into the lungs. Anæsthesia in these cases may be induced in the ordinary way, but after the tracheotomy tube has been inserted, the administration must be continued by means of chloroform in a Junker's apparatus with a metal tube attached; the end of this tube being held close to the orifice of the tracheotomy tube. Either a deep chloroform anæsthesia must be maintained; or, a moderate general anæsthesia combined with a local spray of cocaine. The latter is the safer plan.

Apart from these operations on the upper air passages, other conditions of the neck cause trouble, through interference with the breathing by pressure on the trachea from without. Thus, no closed method of administration must be employed when there is a large goitre or extensive swelling of any kind which is already causing dyspnœa. A light chloroform anæsthesia is alone suitable in such cases; for any closed method will cause an increase of the swelling, and may entirely stop the breathing. These are the cases in which most of the deaths under nitrous oxide gas have occurred. Tracheotomy below the seat of the obstruction may be impossible. When there is an enlarged thyroid, the possibility of the existence of the

[1] See also p. 71.

"status lymphaticus" must always be borne in mind, as it would somewhat alter the mode of administration.

Even when there is no dyspnœa before commencing the operation, neck cases have certain difficulties of their own. The first of these is due to the fact that the surgeon may require his patient to be in a position which is not the best for free breathing. Another is caused by pressure on the trachea by the surgeon or his assistant during the operation. The opening of the pleura, or a large vein in the neck may be attended by disastrous results; and the interference with important nerves may cause sudden and severe cardiac or respiratory embarrassment. Many of these operations are very prolonged, which increases the tendency to shock.

Finally, the bandaging may obstruct the respiration; and therefore, the anæsthetist should never leave his patient until he is satisfied that the breathing is not hampered. A bandage which appears loose enough while the patient is on the operating table may cause obstruction owing to some alteration in the relation of the parts when the patient is put back to bed. He requires, therefore, careful watching until he has regained consciousness.

D.—Obstetric Operations.

In **Normal labour,** a few whiffs of chloroform on a piece of lint during each pain is usually sufficient. Unless the pain be severe and strong, it is better to give no anæsthetic at all; but a little, if only given *during* the pains, and not between them, will not appreciably prolong the labour, or increase the risk of *post-partum* hæmorrhage.

For **Turning, or Delivering the Child with Forceps,** and for **Gynæcological Operations** generally, a profound narcosis is required; and unless there be some contra-indication, ethyl chloride and ether should be employed, and pressed to the fourth degree, provided the respiration be quite free.

E.—Operations on the Chest, Pleura or Lungs.

During the **Removal of the Breast,** shock may be severe, owing to the large number of nerves that are cut by the extensive incision, the considerable hæmorrhage that often occurs, the large surface exposed, and the length of time occupied if glands are extensively involved. The mode of preventing the second of these causes is obvious, and for the third, Mr. Stanley Boyd has recently been in the habit of covering the whole of the raw surface—except the portion that he is actually engaged upon at the moment—with a sheet of india-rubber wrung out in a warm lotion: this prevents loss of heat from evaporation taking place. The first and last factors cannot be avoided; but the operation should be performed as quickly as is compatible with efficiency.

Whenever possible, anæsthesia should be commenced by nitrous oxide gas or ethyl chloride, and then continued with ether from an Ormsby's inhaler. This will not be in the way of the operator if the patient's head be turned away from the affected side, as it should be; and ether is preferable to chloroform or to the C.E. mixture, at least for the earlier part of the operation, when a profound narcosis is required. If the patient be very old or obese, induction must be brought about by C.E. in a Rendle's mask, or open inhaler; but even then it is usually possible to change to ether when the patient is under.

In cases of **Empyema, Pleurisy with large effusion,** and **Pericarditis with effusion,** the anæsthetist frequently has to contend against extra difficulties caused by the position in which the patient must lie. If possible, the sound lung should always be uppermost, but if the operation cannot be performed in this position, anæsthesia should be induced while the patient is lying comfortably, and he must then be turned over as required very gently, and immediately put back if he cannot breathe in the new position. In cases of pericarditis or pleurisy, in which the heart's action, or the respiration, or both, may be hampered by the effusion, the patient will probably be unable to lie down until some of the fluid has been withdrawn. This withdrawal must be gradual, otherwise severe collapse may ensue: and the pillows must be removed one by one as the condition indicates. If there be an **abscess of the lung** the patient *must* lie on the diseased side to prevent the possibility of pus or blood entering the bronchus of the opposite side. The weight of the uppermost arm may hamper the breathing by pressing on the chest; so this arm must either be supported by an assistant or by the simple apparatus shown in fig. 1 designed by Mr. Carter Braine for use in kidney operations, during which a similar position of the patient is required. In all these cases the lightest possible anæsthesia must be maintained. It is imperative that the *coughing reflex should never be abolished;* a little movement on the part of the patient will not interfere with the operation. This state is best produced by means of a mixture of chloroform and ether on a Skinner's frame or in a Rendle's mask; the choice of the inhaler and the exact strength of the mixture depending upon the age and precise condition of the patient.

F.—Abdominal Operations.[1]

During these operations the temperature of the room should be kept at about 75° F; and as much as possible of the patient should be covered by blankets.

It is sometimes advisable to wash out the stomach before commencing to anæsthetize a patient suffering from **intestinal obstruction** if vomiting be very frequent; also occasionally a hypodermic injection of morphia may be serviceable in certain severe cases. If possible the patient should lie flat on his back with his face turned to one side; but the surgeon may require the Trendelenburg position, which sometimes hampers the breathing considerably by the weight of the abdominal contents pressing upon the diaphragm. On the other hand, the patient may be unable to lie down at all when there is great abdominal distension, so it may be necessary to induce anæsthesia in the sitting or semi-recumbent posture.

The choice of the anæsthetic in abdominal operations must depend upon the patient's condition at the time. If he be healthy and the operation be for the radical cure of hernia, stone in the bladder, chronic appendicitis, or other condition not attended by acute symptoms at the time of the operation,

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[1] See also p. 74.

anæsthesia should be induced by means of ethyl chloride or nitrous oxide gas, and maintained in a deep stage by ether administered from an Ormsby's inhaler. Some surgeons prefer chloroform, but this is not necessary or advisable; for, provided the respiration be kept perfectly free, a *deep* ether anæsthesia usually causes no more troublesome abdominal movement than chloroform. Further, as the patient must be deeply under the influence of the anæsthetic ether is far safer than chloroform. A compromise is sometimes made in the choice of the anæsthetic for these cases, by employing ether for operations below the umbilicus and chloroform for those above that level. If desired, the ether can be replaced by chloroform after the patient is fully under.

If the patient be acutely ill or greatly collapsed, ether cannot be administered, or at least not from a closed inhaler. Under these circumstances, the C.E. mixture should be given in a Rendle's mask (or an open mask in the case of a child), and a light degree of anæsthesia maintained, especially if the patient be under the influence of morphia. If there be very severe shock, ether in the Rendle's mask may be substituted for the C.E. mixture during the course of the operation.

As stated above, the stomach may be washed out before the administration, in cases of intestinal obstruction with severe vomiting; but this is not sufficient. The patient's head must be kept turned well over to one side, and the mouth should be opened a little way with a small dental prop placed between the teeth, so that any vomited matter may pass directly out of the mouth. The stomach contents sometimes regurgitate into the mouth without the slightest effort of vomiting being noticeable, and may suffocate the patient unless every precaution be taken.

G.—Kidney Operations.[1]

Patients undergoing operations on the kidneys seem particularly liable to suffer from shock. They are also required to lie in a more or less prone position, which interferes with free breathing. For both these reasons, it is better to employ ether than chloroform for producing anæsthesia, especially as the latter must be profound. The difficulty in breathing due to the constrained position can be decidedly lessened by using a Braine's arm support (fig. 1) which takes the weight of the uppermost arm off the chest.

H.—Operations on the Rectum, Bladder, and External Genital Organs.

In these cases a very profound narcosis is required; and consequently chloroform is unsafe and should always be avoided if possible. A further reason for avoiding chloroform in these cases is that the lithotomy position may be required, and this is obviously not the most favourable position for the performance of free breathing. Ether, preceded by nitrous oxide gas or ethyl chloride, should be administered from an Ormsby's inhaler until the fourth degree of anæsthesia is reached; and this degree should be maintained during the greater part of the operation. In elderly

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[1] See also p. 75.

and obese subjects, the ether may be preceded by the C.E. mixture in a Rendle's mask. Young children give the best results with a mixture of chloroform and ether on lint, the proportion of the ether being as large as possible. During dilatation of the anus, ether alone may with advantage be poured on the lint.

During light anæsthesia, there is a great danger of these cases suddenly dying from cardiac failure. I have recently heard of two cases of sudden death during the passage of a bougie into the urethra after a local injection of cocaine; and moreover, of two similar cases of sudden death when no anæsthetic whatever had been used, either local or general. It would therefore seem that we must seek for safety in a *deep* degree of anæsthesia, produced if possible by ether.

In connection with bladder surgery, it must be remembered that the secretion of urine is more copious during an inhalation of chloroform than of ether: hence, when an anæsthetic is given for a cystoscopic examination during which the surgeon wishes to see the urine entering the bladder from the ureters, chloroform should be employed in preference to ether.

I.—Operations on the Brain and Spinal Cord.[1]

In these operations the surgeon usually prefers the patient to be anæsthetized with chloroform, as this lessens the cerebral blood supply, and for the same reason an injection of morphia is sometimes given beforehand. This latter procedure, however, alters to

[1] See also p. 76.

some extent the ordinary signs due to the anæsthetic, and thereby adds to the risk of what are already sufficiently difficult cases. If morphia has been administered, the anæsthetist should always be informed of the fact, and should endeavour to maintain a state of analgesia rather than a true anæsthesia. Though chloroform may be the nicest drug from the surgeon's point of view, it is frequently absolutely necessary to use the C.E. mixture or even plain ether, on an open or semi-open inhaler, on account of the respiratory or cardiac depression due to increased pressure on the brain, as for example, in hydrocephalus. Any respiratory difficulty that may have existed at the commencement of the operation will frequently be rectified when the pressure has been relieved.

Obviously, if the patient be actually comatose, no anæsthetic at all will be required ; and if he be more or less drowsy, only sufficient of the drug should be administered to procure tranquillity. About the average amount of chloroform or C.E. may be required to *induce* anæsthesia ; but this condition can afterwards be maintained, in the majority of cases, with very little of the drug.

It is more than ever necessary, in this class of case, for the anæsthetist to be provided with emergency appliances, including a hypodermic syringe *in working order* filled with strychnine or other stimulant ; for troubles are liable to arise very suddenly. One instance may be quoted in support of this statement : chloroform was being administered to a soldier who had a severe bullet wound of his skull, several small pieces of bone being driven into the dura mater, causing an abscess to form close under the surface of the frontal lobe. The pulse-rate at the commencement of the operation was 110 per minute; but at the moment of opening the abscess, the patient suddenly became blanched; and his pulse, when felt, was found to have fallen to thirty-four beats per minute. Brandy was the only stimulant at hand, and this was immediately injected under the skin, while the head was lowered. The patient gradually recovered, and for the remainder of the operation, which lasted one hour, the anæsthesia continued normally.

In spinal operations, there is an added impediment to the breathing caused by the necessary position of the patient; and in such cases ether is usually essential.

J.—Operations upon the Eye.

The administration of anæsthetics for these operations is very difficult. Chloroform or the C.E. mixture must be used; because the salivation, which ether causes, would give rise to great difficulties owing to the necessity of keeping the face directed upwards. This position, moreover, tends to cause obstruction to the breathing from the tongue gravitating towards the back of the pharynx.

The anæsthesia must be very profound, and the anæsthetist has to judge of the condition of his patient without being able to make use of the eye signs, which are frequently abolished by cocaine, and either eserine or homatropine, according to circumstances. These cases appear to be particularly prone to sudden attacks of syncope.

There is a certain danger in employing a Skinner's mask in these cases, as the patient may be absorbing an overdose of chloroform, and yet it may be impossible to remove the inhaler from the face without jerking the operator's hand, which he frequently rests upon the mask. I therefore prefer to use a Junker's inhaler; as by this means, the supply of chloroform vapour may be diminished or stopped at will without removing the facepiece. For this purpose, Messrs. Duncan and Flockhart have made for me the mask shown in fig. 5. It is almost the same as the ordinary flannel mask generally used with a Junker's inhaler,

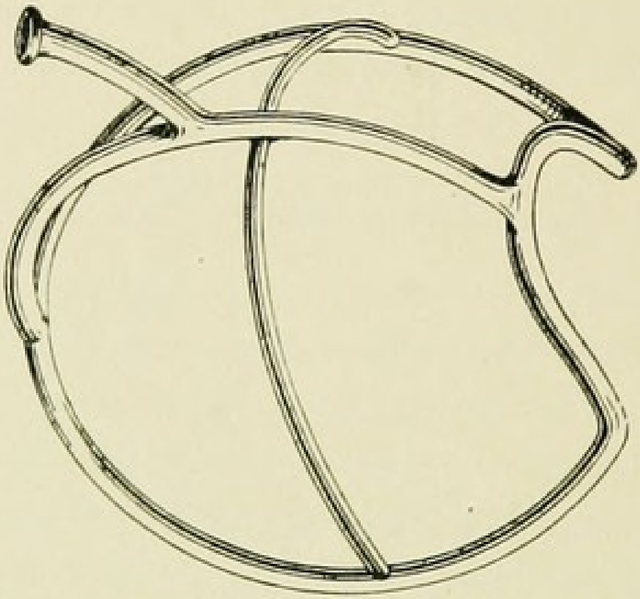

FIG. 5.—The Author's Chloroform Mask for use during Ophthalmic Operations.

but the apex is cut away so as to leave more room round the eyes.

K.—Accident Cases.

Patients who have recently met with an accident, such as a dislocation or fracture, may require an anæsthetic for the immediate reduction or setting of the same.

The difficulties that may arise in such cases are due to the following causes: (1) The patient is frequently under the influence of alcohol; (2) a meal may have been taken recently; (3) the rectum may be loaded; (4) the shock of the injury is still present. For all these reasons, ether is indicated in preference to chloroform. It may be preceded by ethyl chloride in an Ormsby's inhaler, or a little C.E. in a Rendle's mask; or the ether may be administered *ab initio* on an open inhaler.

For cases of severe injury to the lower extremities, attended by great shock, some surgeons now employ spinal injections of stovaine; by means of which all further impressions from the seat of the injury are cut off in the lumbar region, and prevented from reaching the brain; thus markedly diminishing the shock.

The reduction of dislocations, especially of the shoulder-joint, is said to predispose the patient to syncope; and this danger is greater when chloroform is employed. According to Dastre,[1] the breaking down of adhesions is attended by even greater risk.

3.—The Use of Anæsthetics in the Treatment of Certain Diseases.

In addition to their employment as an adjunct to a surgical operation, anæsthetics are occasionally used also as the definite treatment of certain spasmodic diseases or conditions. The chief of these are *asthma, colic, whooping cough, eclampsia, angina pectoris, tetanus, and strychnine poisoning.*

In most of these cases, full surgical anæsthesia is not required, but eclampsia is an exception to this rule; and the other conditions mentioned may occa-

[1] Dastre, "Les Anesthésiques," p. 136.

sionally require full anæsthesia; but, generally speaking, a light narcosis to relieve the spasm is all that need be aimed at, and it may best be obtained with chloroform. It is seldom that an anæsthetist is called in to these cases, and my personal experience is limited to asthma and angina pectoris. In the latter of these, ether would seem to be decidedly contraindicated, as it would cause increased action of the heart, but a small dose of chloroform on a handkerchief soon brings relief to the sufferer. In asthma, I have twice anæsthetized the patient with chloroform until sleep was produced, and then left him: the result on each occasion being a perfect night's rest, which was the first for several nights. Ether inhalations have also been reported as relieving asthmatic attacks.

It has been pointed out that if a child with whooping cough be fully anæsthetized with chloroform, not only will the immediate spasm be relieved, but the number of seizures per diem, and their severity, will be considerably lessened during the remainder of the illness.

Summary.

For the sake of clearness and easy reference, it may be well to tabulate the chief indications for the different anæsthetics; but it must be remembered that the same patient may come under more than one heading, and events may arise during the administration requiring a change of the drug.

(1) Indications for Nitrous Oxide Gas (with air or oxygen):—

Dental operations requiring not more than forty seconds in adults, or twenty seconds in children.

Short surgical operations, in which rigidity and some slight reflex movement do not matter.

(2) Indications for Ethyl Chloride :—

Dental operations in children, when not more than two teeth are to be extracted.

Prolonged dental operations in adults (sometimes nitrous oxide can be administered through the nose for these cases).

Removal of tonsils and adenoids in children, and sometimes in adults; also many nasal and aural operations.

Minor surgical operations lasting about five minutes, or even ten minutes, in which nitrous oxide would not keep the patient quiet enough.

Removal of first dressings after an operation; and various painful examinations and manipulations.

(3) Indications specially demanding Ether :—

Hysterical women, and patients who are in a great state of fright.

Muscular patients.

Alcoholic patients.

Patients suffering from severe shock.

Operations upon the rectum and genital organs.

Most abdominal operations.

Patients who have previously exhibited dangerous symptoms during the administration of chloroform.

Ether should also be employed as the *routine* anæsthetic in cases presenting no special contraindications.

(4) Indications for the C.E. Mixture :—

Infants and young children.

People over 65 years of age.

Extreme obesity.

Advanced morbus cordis (with failure of compensation).

Recent diseases of the lungs or pleura.

Some abdominal operations.

Patients who are acutely ill at the time when an operation has to be performed.

(5) Indications for Chloroform :—

Natural labour.

Operations in and about the mouth, nose, and upper air-passages.

Cases of renal disease.

Patients suffering from dyspnœa with cyanosis.

Marked atheroma.

Aneurysm.

Operations on the brain and its membranes, as a rule.

Operations during which the cautery, or a naked light is to be used near the mouth.

(6) Conditions in which either Chloroform or the C.E. Mixture may be used :—

Patients who have suffered previously from cerebral hæmorrhage.

Intolerance of ether.

Affections of the air-passages.

Mitral stenosis.

CHAPTER VI.

THE ADMINISTRATION OF NITROUS OXIDE GAS.

In the present day, this gas is seldom administered without the addition of either air or oxygen: and since this volume is to be confined to the practical side of the question, all the earlier methods which are now out of date must be omitted. There are primarily three distinct methods of administering nitrous oxide gas, which will be described in three sections:—

(1) The ordinary administration of gas and air.

(2) The administration of the gas by the nasal method.

(3) The administration of nitrous oxide gas with oxygen.

Unless otherwise stated, it is presumed that the patient is sitting in a chair for a dental operation, since this is the most frequent occurrence when nitrous oxide is required.

1.—The Administration of Nitrous Oxide Gas with Air.

The apparatus required consists of two steel cylinders containing the liquefied gas (A, fig. 6) which are coupled together by a union (E), and fixed by means of screws and nuts to a stand (F). The supply of gas from the bottles is regulated by the foot-screw (G) and passes up through an india-rubber tube (B) into a bag of the same material (C). From this bag the gas passes to the face-piece (D) through a stopcock (H, figs. 6 and 7). The two stopcocks in most general use are Barth's (fig. 6) and Hewitt's (fig. 7). Of the two, Barth's is the simpler and less likely to get out of

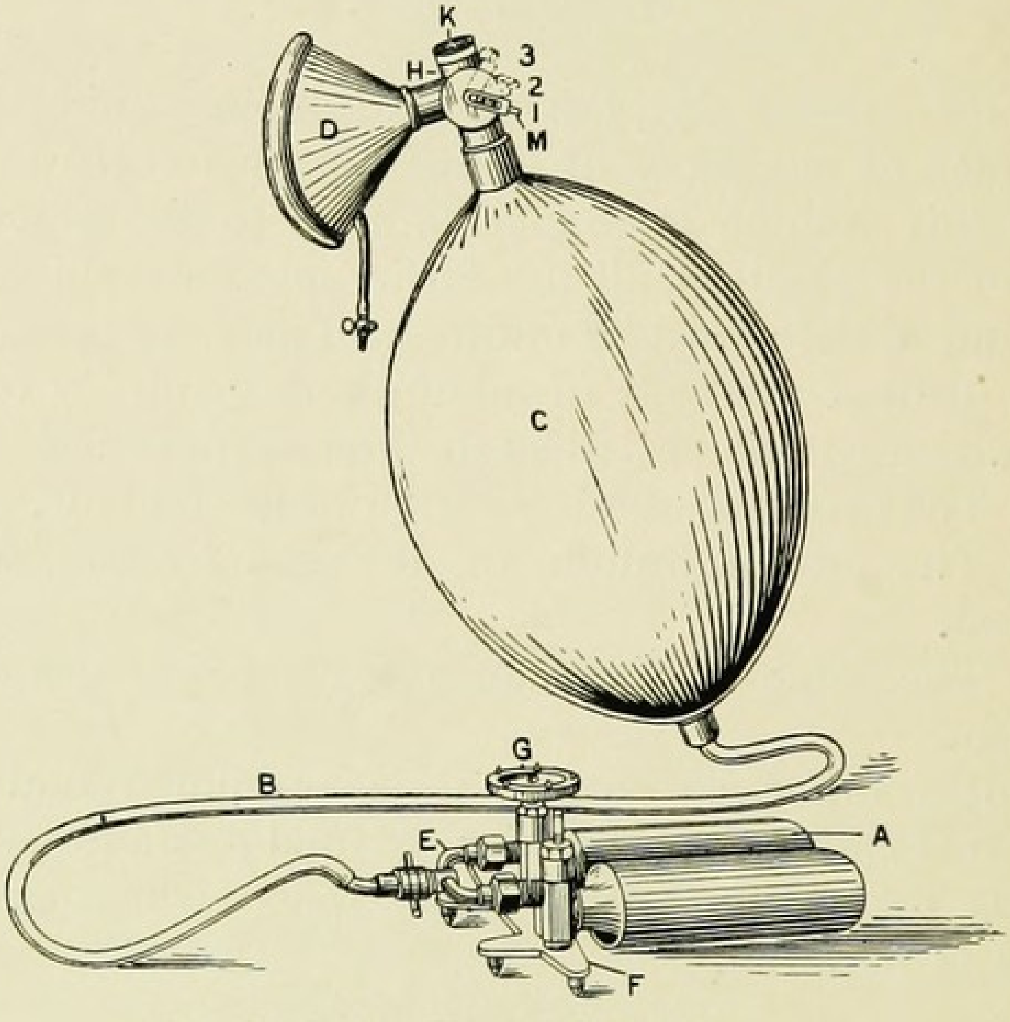

FIG. 6.—Barth's Nitrous Oxide Apparatus.

working order; but with Hewitt's, the patient always breathes through the same valves whether he is being given air or gas, and he therefore notices no alteration to his usual breathing when the gas is turned on. This is not so with Barth's apparatus, in which the gas passes through valves, but the air does not. This is of importance with a nervous patient.

The union (E) delivers the gas from both cylinders to the rubber tube (B), but care should be taken to keep one of the bottles always full in reserve. The bottle in use can be marked on the label, and this

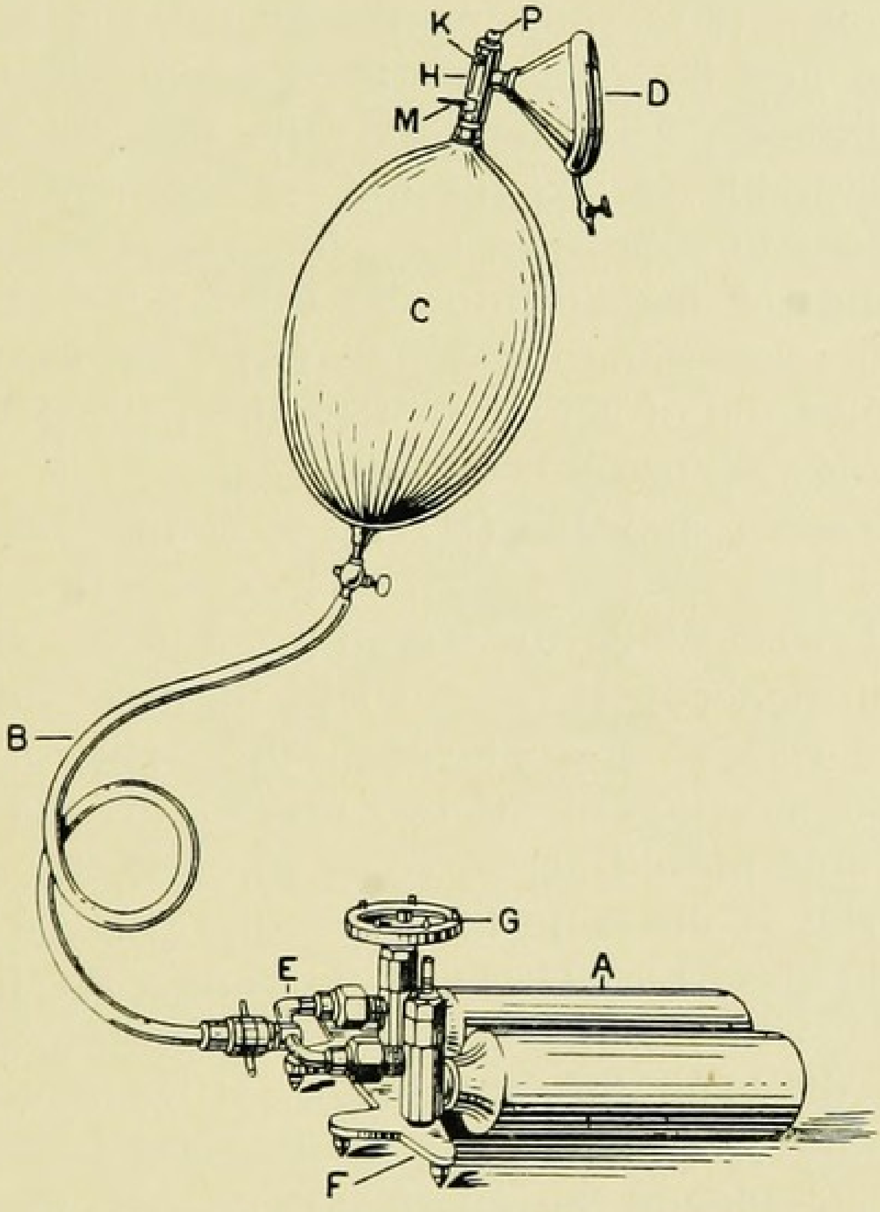

FIG. 7.—Hewitt's Nitrous Oxide Apparatus.

bottle should be employed each time until it is empty, otherwise both bottles may be found to be empty at the same time in the course of an administration. Barth's stopcock (H, fig. 6) is worked entirely by one handle (M), which has three positions. When it is in position 1, the patient breathes air without the intervention of any valves. If the handle be now raised to position number 2, the air aperture is closed, and the gas is able to pass up from the bag into the face-piece, whence it is inspired by the patient. During expiration a valve shuts off the aperture between the stopcock and the bag, and the expired air and gas escape through the expiratory valve (K). It is sometimes desirable to prevent this escape, and to cause the patient to rebreathe into the bag: this is done by raising the handle into the third position, which closes the expiratory aperture (K) and throws the other valve out of action, so that the patient breathes backwards and forwards into the bag.

In Hewitt's stopcock (H, fig. 7) similar results are obtained in a different way. There are two handles (M) and (P). When these are turned in the direction shown in fig. 8, air is breathed in through the orifice (N), and escapes again through the expiratory valve (K) in the direction of the two arrows. If the handle (M) be now moved across so as to close the air inlet (N), it will at the same time open the passage leading from the gas-bag. Gas will then pass up into the face-piece without any air, and will be breathed out through the expiratory valve (K). If we now reverse the handle (P), the orifice of this expiratory valve will be closed, and the valves thrown out of gear; so that breathing takes place backwards and forwards into the bag.

When about to administer nitrous oxide gas to a patient, first see that all the valves are in proper working order; then squeeze out any air that may be in the bag, and set the handles of the stopcock as shown in fig. 8 (or fig. 6, if Barth's apparatus is being used). Next make sure that the screws or nuts attaching the union (E) to the cylinders are tight. After these preliminaries the bag should be filled to the extent of about two-thirds with the gas by turning the foot-key (G), and the latter should then be screwed lightly down again. The apparatus is now ready for use. If possible, these preparations should be made just before the patient enters the room; because sometimes the gas rushes out of the bottles rather

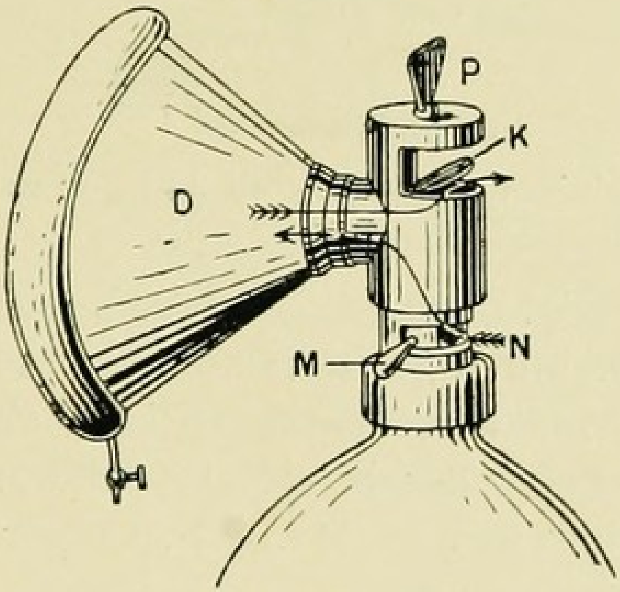

FIG. 8.—Hewitt's Stopcock for administering Nitrous Oxide Gas.

suddenly at first, and the noise may terrify a nervous patient. The patient must now loosen any tight bands or clothing round the neck, waist and chest; and then sit in the chair, the height and angle of which must be adjusted *before* the administration is commenced. The head-piece of the chair must be arranged in such a way that the patient's head is in a straight line with the body, neither flexed with the chin on the chest, nor thrown backwards, in which position blood, or perhaps a tooth slipping from the forceps, might possibly enter the larynx.

The anæsthetist's next duty is to place in position a suitable mouth-prop. These are of various sizes

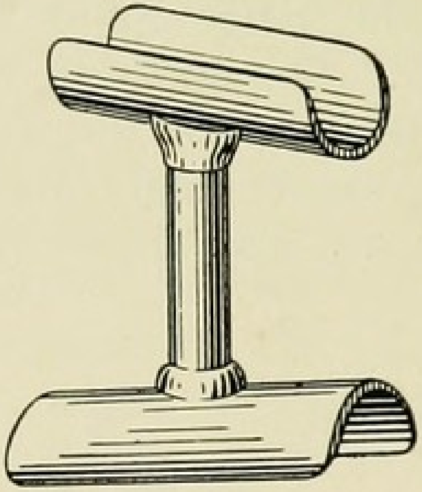

FIG. 9.—Hewitt's Mouth-prop for use during dental operations.

and shapes. Fig. 9 shows a Hewitt's prop: it is made of aluminium, and has india-rubber pads to fit over each end. One end of the prop is at right angles to the bar, and the other is set at such an angle as to fit the jaws when apart. Mr. J. F. Colyer has modified

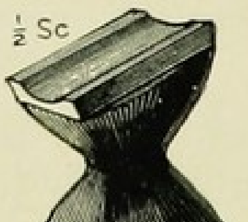

FIG. 10.—Vulcanite Mouth-prop.

this gag by moulding lead into the concave surfaces for the teeth to bite on, instead of using rubber pads. The gag so modified is more easily cleaned than Hewitt's, and Mr. Colyer thinks it is less likely to slip.

Fig. 10 shows a somewhat similar type of prop, made of vulcanite, and tipped with thick rubber.

Whichever of these props be chosen, it must be placed far back on the side opposite to that on which the extraction is to take place. If teeth are to be removed from both sides of the mouth, one of these

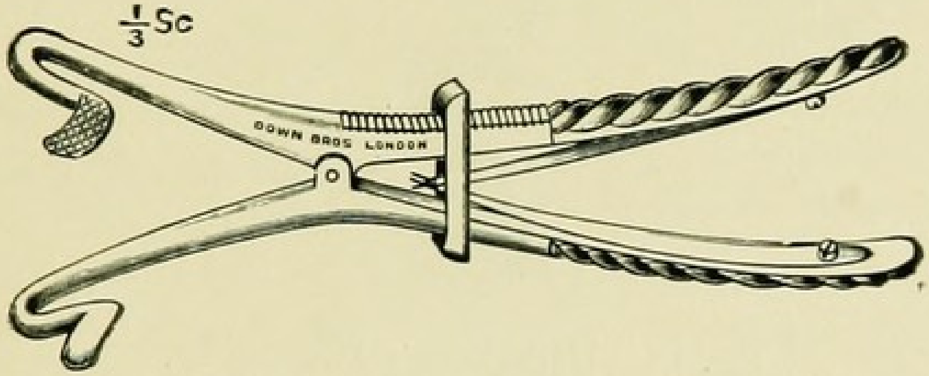

FIG. 11.—Fergusson's Gag.

props may be used while the dentist works on one side; and then a Fergusson's gag (fig. 11) can be inserted on that side, while the prop is removed, and the teeth extracted from the other side. Care must be taken not to dislocate the jaw when this change is made.

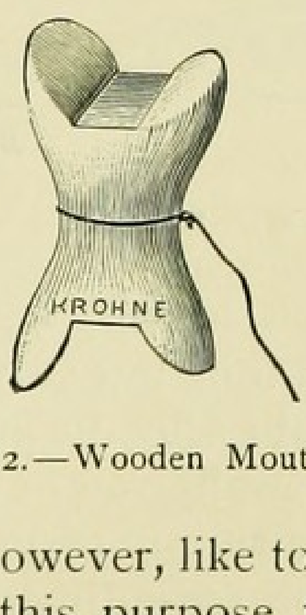

FIG. 12.—Wooden Mouth-prop.

Some operators, however, like to avoid this necessary changing, and for this purpose they employ a prop which can be placed between the front teeth, so that both sides of the mouth can be reached. For this purpose the plain wooden prop shown in fig. 12 is cheap, clean and convenient. Underwood's prop (fig. 13) is similar, but made of vulcanite with thick rubber ends.

Fig. 13.—Underwood's Mouth-prop.

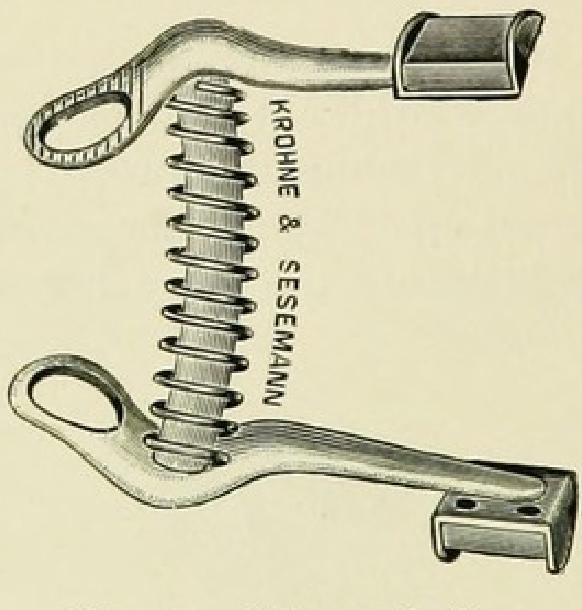

Fig. 14.—Wingrave's Gag.

These props should always be joined together in pairs with a piece of thin but strong string, so that if the prop in the mouth slip during the inhalation of the gas, it cannot be swallowed or inhaled.

To avoid keeping a supply of props of various sizes, some are made to be self-adjustable, by means of a spring. The best of these is Wingrave's (fig. 14), the tooth-plates of which are on hinges so that the handles may be swung round to the opposite side to that on which the operation is being performed.

Care must be taken to see that the prop is firmly fixed between sound teeth, so that it is unlikely to slip, or to injure the teeth upon which it rests. The anæsthetist should then take up his position on the left side of the patient or behind the chair, in either of which places he will be out of the dentist's way.

Now the face-piece may be fitted to the patient's face, and it must fit accurately so as to exclude the possibility of any air leaking in around it; for this purpose all modern face-pieces are made with an air-cushion round their free edge which can be blown up to the necessary extent. If the patient has a stiff beard, it is sometimes very difficult to prevent some leakage.

When first applied, the handles on the stop-cock should be turned in such a way that air is breathed backwards and forwards through the apparatus; and no gas should be turned on until it is quite certain that the face-piece is fitting, that the valves are working properly, and that the patient is breathing freely. He must be told to "breathe slowly through the mouth, and blow out hard," which phrase, if somewhat ungrammatical, is at any rate intelligible, even to a very nervous patient.

The air-inlet may now be closed and the gas turned on. At the same moment the foot is pressed firmly on the foot-key, and the latter is rotated, so as to keep the bag nearly full throughout the administration. A strong healthy man requires a greater pressure of gas in the bag than a weak, anæmic girl, or a child; likewise the pressure must be increased if any excitement or noise occurs, but diminished if jactitation appears too quickly. The actual amount of pressure that should be maintained in the bag can only be learned by experience.

After a certain number of inspirations of nitrous oxide from the bag (generally about twelve), the breathing becomes quicker and deeper owing to the want of oxygen. The handle (M, figs. 6, 7, and 8) should now be turned so as to allow one full inspiration of air, and then immediately returned to its former position. From this time up to the end of the inhalation, one breath of air will be necessary after about every six or eight breaths of the gas; the frequency being regulated according to the symptoms. Thus, cyanosis, large pupils, deep breathing and twitchings would indicate the necessity for more air; whereas a heightened colour, noise, apnœa, movement and excitement would denote that too much air was being given. Except under very exceptional circumstances, the patient should never be made to breathe backwards and forwards into the bag, as this is unnecessary (unless the gas is to be followed by ether in a Clover's inhaler); it is also a dirty practice, and it increases the after-symptoms, especially headache.

The average length of time taken in inducing anæsthesia by nitrous oxide gas with air is about a minute and a half for an adult; and the resulting anæsthesia lasts about thirty seconds after the removal of the face-piece. About six gallons of the gas are required for an average patient.

Where thirty or forty cases have to be anæsthetized in succession, as in a dental hospital, it is convenient to use a gasometer instead of the bottles. This may be charged with 50 gallons or so at the commencement, and then the bottles need not be touched again until all the gas in the gasometer is used up. The rest of the apparatus remains the same, the bag being kept constantly filled by the gasometer. The drawback to this method is that the pressure of the gas cannot be varied at will during an administration. The details of the administration are the same as when the gas is supplied direct from the bottles.

2.—The Administration of Nitrous Oxide Gas by the Nasal Method.

Various methods have been devised for prolonging the administration of nitrous oxide gas during a dental operation: the best of these is Paterson's. His plan consists of giving the gas through a small-sized and specially constructed face-piece, which fits over the patient's nose, leaving the mouth free, so that the dentist can remove teeth from the mouth while the administration of the gas proceeds.

The apparatus is shown in fig. 15, and consists of two cylinders, foot-key, union and stand as in the ordinary gas apparatus. But the tube (B) conveys the gas to a smaller and stronger india-rubber bag (C). Immediately above this bag is the stopcock (H), suspended by a chain and hook (L) which can be attached to some convenient part of the chair. In the stopcock is a handle (M) which turns into two positions; one as shown in the figure, in which gas is passing out of the bag into the two tubes (T): and the other at right angles to the first, in which the gas is shut off and air enters through the opening (N) instead. The two tubes (T) convey the gas, or the air, to a nose-piece

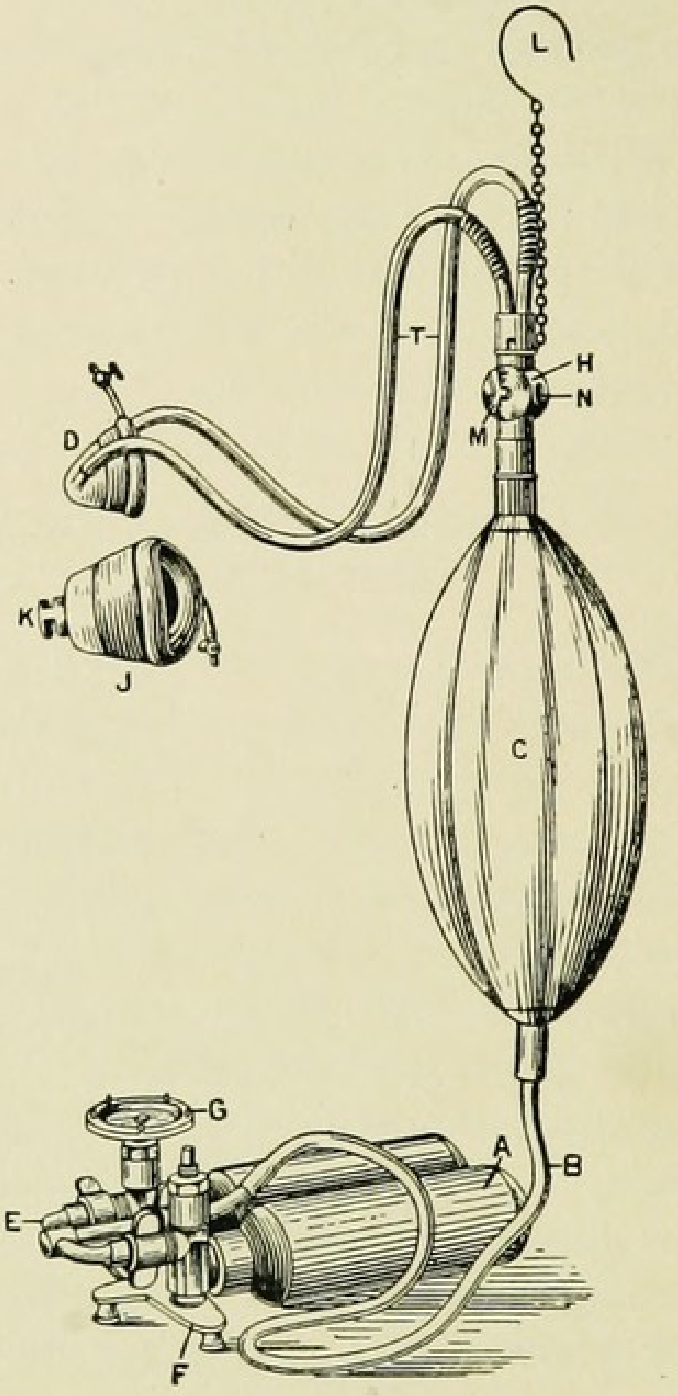

FIG. 15.—Paterson's Apparatus for administering Nitrous Oxide Gas through the nose during prolonged dental operations.

(D), which is about 2 in. long and $1\frac{1}{2}$ in. wide. There is also a mouth-piece (J) fitted with an expiratory valve

(K), which may be used if desired; but it is not usually necessary.

To administer nitrous oxide gas by this method, the patient should be prepared as usual, and the mouth propped open. In this case a central prop is of advantage when both sides of the mouth have to be operated upon, as the anæsthetist's hands are occupied all the time with the apparatus, so that it is very difficult for him to insert a Mason's or Fergusson's gag during the operation.

The bag (C) should be nearly filled with nitrous oxide gas, and the tap (M) turned so as to prevent the escape of the gas and admit air through the hole (N). The nose-piece is now firmly placed over the patient's nose, and made to fit accurately. The patient is then told to breathe *in* through the nose and *out* through the mouth; and when he begins to do this properly, the tap of the stopcock may be reversed, shutting off the air and permitting the gas to pass up to the nose-piece. At the same moment the foot-key must be turned, and the pressure of the gas in the bag gradually increased till there is a slight positive pressure; and from this time onwards the key must be so worked as to increase the pressure of the gas at the commencement of each inspiration, and cease to increase it before the expiration commences. If this be done well, and at the right moment, the mouth-piece (J) need hardly ever be employed. But occasionally, owing to nervousness or other cause, the patient cannot be made to breathe properly; and in these cases the mouth-piece must be applied. It is fitted with only one valve (K), which allows the expired air to escape freely; but no air can enter through it: so, when this piece is used, the patient must of necessity breathe in through the nose and out through the mouth. The mouth-piece should be avoided when possible, as its use increases the discomfort of the patient.

The inhalation of the gas should be continued until the patient becomes a little cyanosed, and the breathing is deep and attended by a coarse, snoring sound; then one breath of air should be admitted through the stopcock, and at the same time the operation may commence. After this, a breath of air must be allowed after every five or six breaths of the gas so long as the inhalation lasts. With this method, as the gas is administered throughout the whole operation, it is obvious that more gas will be used than in the ordinary method; and, consequently, the after-effects will be more marked. On the other hand, as many teeth may be extracted in this way at one sitting as would be possible in some cases in six sittings where the ordinary method was employed.

3.—The Administration of Nitrous Oxide Gas with Oxygen.

The most practical method of administering nitrous oxide gas with oxygen is that of Dr. Hewitt. After many years of experimenting with different forms of apparatus, he has now devised one which works admirably, and appears to be all that is required.

As shown in fig 16, it consists of three steel cylinders (A, B and C), fixed on a stand, and coupled in such a way that the oxygen contained in the cylinder (A) passes into the tube (D), and the nitrous oxide gas, which is in both cylinders (B) and (C), passes through the tube (E). These tubes are connected by a Y-piece in such a way that one runs up inside the other; and they eventually separate again by another Y-piece just before entering the bag. This latter is divided down

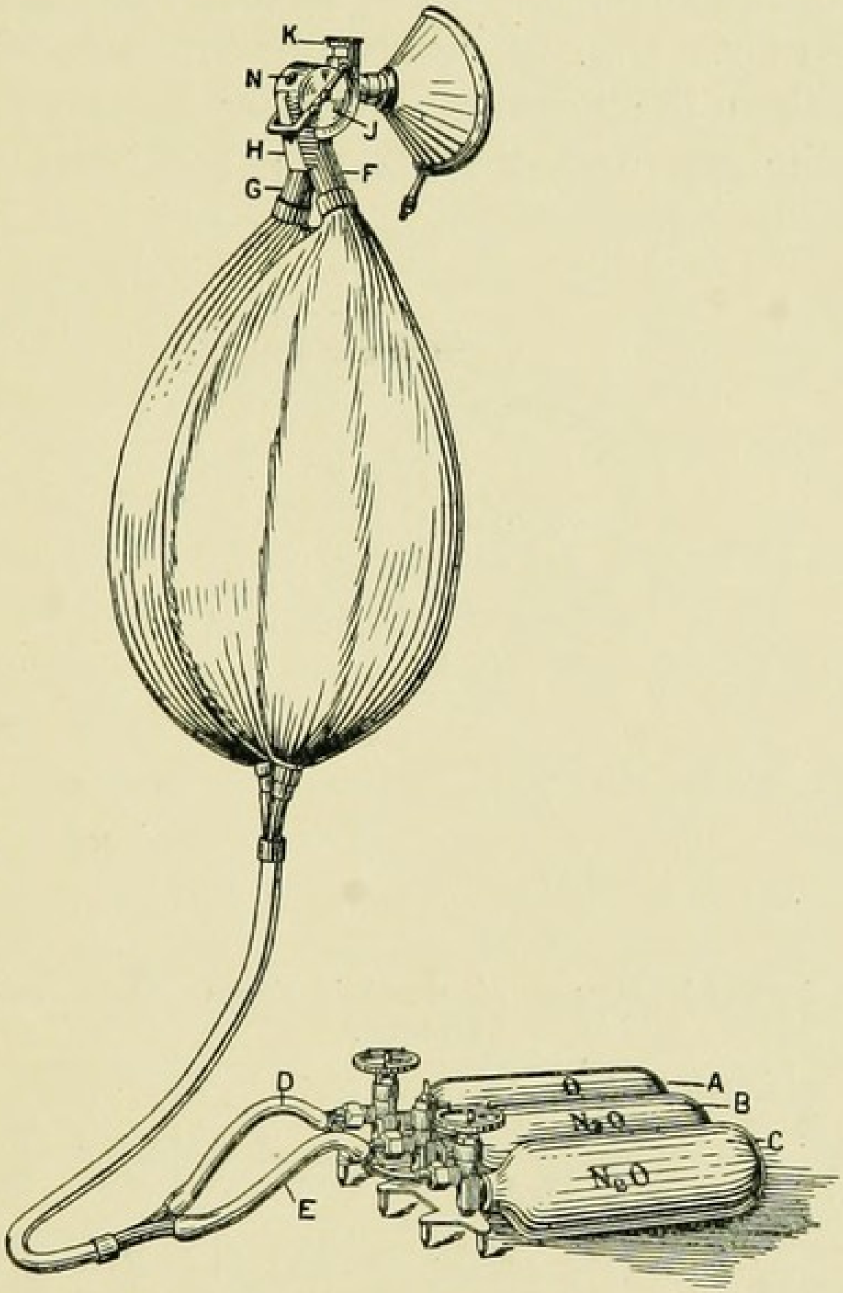

FIG. 16.—Hewitt's Apparatus for Administering Nitrous Oxide Gas with Oxygen.

the middle by a partition which completely shuts off the oxygen on one side from the nitrous oxide gas on the other.

The nitrous oxide gas leaves the bag by the metal tube (F) and directly enters the mixing chamber (J); while the oxygen leaves its half of the bag by the tube (G), and enters the oxygen chamber (H), which has ten small openings into the mixing chamber.

The face-piece is the same as that used for nitrous oxide with air. Fig. 17 shows the stopcock on a larger scale. When the lever is placed as shown in figs. 16 and 17, the gas and the oxygen are both shut off,

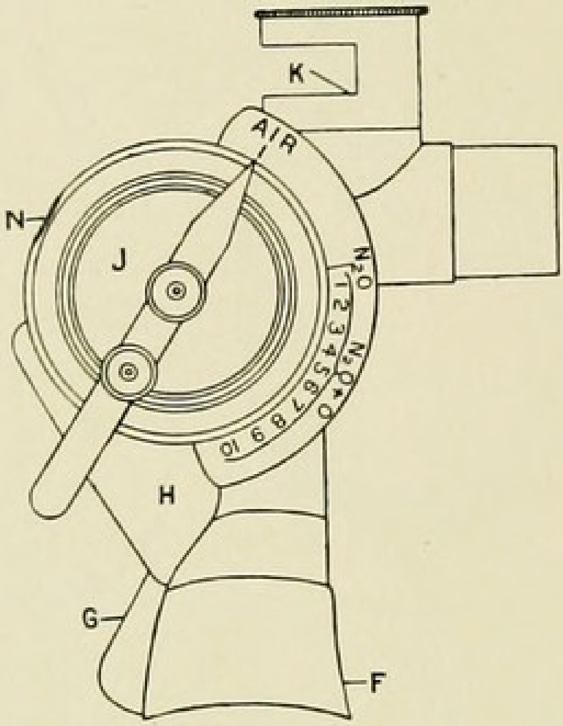

FIG. 17.—Enlarged diagram of Hewitt's Nitrous Oxide and Oxygen Stopcock.

and the air-inlet (N) is opened. The patient then inhales air through this inlet, and exhales it through the expiratory valve (K).

If the handle be now raised till the pointer is opposite "N_2O" on the scale, the air-inlet is closed, and nitrous oxide gas passes up to the face-piece; it is still exhaled through the valve (K). As the lever is now drawn further up, the pointer passes in rotation the figures from "1" to "10," which indicate that the aperture from the nitrous oxide bag remains always fully open; but in addition the ten small holes leading from the oxygen chamber (H) into the mixing chamber (J) are opened one by one.

In order to thoroughly understand the exact working of this ingenious apparatus, I think it is essential to obtain one and take it to pieces. There are small rubber valves in the two metal tubes (F) and (G) which allow the gases to leave the bag, but prevent any return. There is a similar valve between the mixing chamber (J) and the face-piece to prevent any expired air from entering the mixing chamber; and there is finally the expiratory valve (K), which permits free escape of the expirations and prevents any air from entering.

To administer the mixed gases from this apparatus, it is of the utmost importance that all the valves be in perfect working order, and that the face-piece fit accurately.

Before commencing the administration, both divisions of the bag should be about two-thirds filled. The oxygen bottle may then be screwed down tightly, as it will not be required any more; but the foot must be kept constantly on the key of one of the nitrous oxide bottles, and must be turned in such a way as to regulate the supply of the gas to its division of the bag, so that both sides of the bag are always kept equally distended. About twenty times as much of the nitrous oxide is used as of the oxygen during the administration.

Now, the patient being settled in the chair, and a suitable prop placed between the teeth, as stated before, the face-piece may be applied to the patient's face, the anæsthetist standing on the left side, and a little in front of his patient. Accurate fitting of the face-piece is essential in order to obtain the best results by this method. The face-piece should be held in the palm of the left hand, the little finger of which is hooked under the lower jaw to keep it up, and so prevent the prop from slipping. At first, plain air should be admitted through the apparatus, by placing the lever in the position shown in fig. 17. This must be continued until the patient is accustomed to the inhaler, and until the valves are *heard* to be working properly. From this moment, not a word should be spoken in the room until the patient has fully regained consciousness, and no movement of the patient or of the chair should be permitted until full anæsthesia supervenes. The lever is now raised until the pointer is opposite the figure "2" on the scale. This is presuming the patient to be an average one: a strong healthy man had better be started with only one of the oxygen holes open, whereas a child or anæmic girl would give a better result if three, or even occasionally four holes, be opened from the commencement. Indeed, if a child be crying, the indicator should be placed at "10" to begin with, as crying always causes a degree of asphyxia. But to return to our average case, when the indicator points to the figure "2" on the scale, the patient is inhaling nitrous oxide gas with the addition of about 2 per cent., or rather less, of oxygen. After inhaling this mixture for a few breaths, the respirations will become deeper and more frequent, owing to anoxæmia. As soon as this phenomenon is noticed, the lever should be moved one or two points (generally two points at a time) till the indicator points to the figure "3" or "4" on the scale. The respiration will then cease to become deeper and more frequent, at least for a time. If, presently, the same thing happens again, or if the face becomes at all cyanosed, or muscular twitchings occur, the indicator must be moved on another one or two points; and so on throughout the administration.

Instead of the respirations becoming quicker and deeper, and the face becoming cyanosed, from insufficiency of oxygen, the patient may begin to move or get noisy; or the breathing may entirely cease for several seconds, while the face remains a good colour, or even flushed. This would mean that a too liberal supply of oxygen was being given, and the indicator must be set back one or two points for a few breaths, but not until the effects have entirely subsided; for the changes due to any increase or diminution in the amount of oxygen supplied are always delayed for a few seconds.

When complete anæsthesia has been obtained, the supply of oxygen should be about halved for the final two or three breaths; as by so doing, we can obtain a longer and more satisfactory narcosis. After this, the apparatus should be removed from the patient's face at the end of an inspiration, and laid aside, the gas supply from the bottle being at the same time cut off by means of the foot-key. The anæsthetist's hands are now free, and he should use one of them to support the patient's head, and the other to support the lower jaw, both in order to prevent dislocation of the jaw during the extraction of a lower tooth, and also to prevent the prop from slipping. If both sides of the mouth are to be operated upon, it is the duty of the anæsthetist to insert the Mason's or

Fergusson's gag at the proper time. When this is used, care should be taken that no weak or loose teeth are broken or knocked out, and that a piece of the mucous membrane of the cheek does not get caught between the gag and a tooth, as this causes considerable discomfort afterwards.

The advantages of administering oxygen with the nitrous oxide gas are :—

(1) The resulting anæsthesia is prolonged from about 30 seconds to about 45 seconds.

(2) The suffocating sensation sometimes felt at the commencement of an inhalation of plain nitrous oxide gas is avoided.

(3) The normal colour of the features is maintained.

(4) Phonation is less common, as a deeper anæsthesia is obtained.

(5) The circulation is better maintained.

(6) The clonic muscular contractions, or jactitations, which are due to anoxæmia, are avoided.

(7) The mixture is safer than plain nitrous oxide gas, especially in cases of cardiac or pulmonary disease.

I have myself anæsthetised patients with this mixture while they were suffering from almost every form of cardiac trouble, including some bad cases of "congenital heart." They required rather more oxygen than usual, but otherwise the anæsthesia was quite normal in each case.

The Signs of Anæsthesia produced by nitrous oxide gas with air or oxygen are :—

Regular deep breathing, accompanied by a soft stertor.

The colour of the face should remain about normal.

The limbs are usually flaccid, but sometimes all rigidity cannot be abolished.

The eyeballs first exhibit a vertical nystagmus, and then gradually settle down and become fixed, usually in a downward and inward direction.

The pupils are generally about semi-dilated.

The conjunctival reflex is abolished, but the corneal reflex usually remains.

Very deep breathing or coarse stertor only occurs when too little air or oxygen is given ; and twitchings of the eyelids, which are the forerunners of general jactitations, have the same significance. The eye signs are the most important, both as indications of the induction of a sufficient degree of anæsthesia, and of the moment at which the operation must be stopped ; but they are not quite constant. During the induction of anæsthesia, if any attempt be made to raise the upper lid, it will be found to resist more or less strongly ; but when anæsthesia is obtained, the lids become quite relaxed. The size of the pupil is variable ; a very widely dilated pupil denotes the want of oxygen ; but, apart from this, the pupil does not help us much. The conjunctival reflex should be abolished before the operation commences, but the latter need not be stopped as soon as this reflex returns. Immobility of the eyeball is the sign upon which we chiefly depend ; the globe may be fixed in any direction, but the best anæsthesia is generally obtained in cases where the eye is turned downwards and somewhat inwards. Occasionally one absolutely fails to obtain this immobility of the eyes, and in these cases the inhalation should be continued for at least two minutes ; at the end of which time a little rolling about of the eyeballs may be disregarded.

When the signs of anæsthesia just mentioned have appeared, the inhaler should not be removed immediately, but kept in place for a few more breaths, as by doing this, a longer and more tranquil anæsthesia is obtained; and it should be finally removed just at the end of an inspiration; as a few seconds are thereby gained, which would be entirely wasted if the inhaler were kept on the face till the end of the following expiration.

The operation must be commenced the moment the face-piece is removed, and the anæsthetist then has to assist the operator as far as he can, and insert a gag if required. He must also watch the patient's breathing and colour, so as to know at once if there be any danger, as well as watching the eyes for signs of returning consciousness. The first change that he will observe here will be increasing lachrymation: the eyes become more moist, and soon afterwards tears collect and then run down the cheeks. Then the eyes begin to roll slowly from side to side; but as soon as they commence to make sudden jerky movements, as though the patient were looking about to discover where he is, the operation must be immediately stopped, otherwise pain will be felt: and if any pain be felt at all, the patient will frequently imagine that he has felt the whole operation, though it may be quite certain that he was only conscious during the very last stages.

The dental prop is best left in place until the patient has completely regained consciousness, for sometimes the removal of the prop is interpreted by the patient as being part of the operation; and he then thinks that he felt something of the extraction.

On recovery, the patient may complain of giddiness, and noises in the ears ; but these soon pass off. Vomiting, I find, occurs about once in 150 cases, but some of these patients had been eating shortly before the administration. When the gas is given without the addition of oxygen, vomiting only takes place about once in 500 cases. The most frequent after-effect of this anæsthetic is headache, and this may cause the patient much trouble for the rest of the day. Fainting also occurs occasionally (usually in children), but this passes off quickly, as a rule, if the recumbent position be assumed and a window opened.

Micturition sometimes occurs during the anæsthesia, particularly in children.

For general surgery, this mixture of nitrous oxide and oxygen has not much to recommend it. It certainly allows the patient to recover more rapidly, and causes less after-effects than when ether or chloroform is used ; but the anæsthesia is not so profound, and reflex movements may take place throughout the operation. There are, however, some cases in which it is very useful, *e.g.*, the removal of first dressings after an operation, the moving of stiff joints, &c., in which cases a little movement would cause no inconvenience. In such cases the inhalation may safely be continued as long as it is required, but as time goes on more and more oxygen is necessary. For this reason Dr. Hewitt has made an addition to the apparatus already described of a small handle by means of which the maximum percentage of oxygen obtainable in the mixture can be raised from about 10 per cent. to about 40 per cent. A prolonged anæsthesia can, however, be obtained with the ordinary apparatus by increasing the supply of oxygen up to the full limit, which is about 10 per cent ; and then in addition giving an occasional full breath of air when required.

CHAPTER VII.

THE ADMINISTRATION OF ETHER.

ETHER may be administered by the closed, semi-open or open method; the first being usually adopted in this country.

The two chief instruments for administering ether by the closed method are the Ormsby's inhaler (fig. 18), and the Clover's portable regulating inhaler (fig. 20). Of these, the Clover is usually more popular amongst general practitioners, while most special anæsthetists prefer the Ormsby, on account of its larger and more direct airway. Another great advantage of the Ormsby's inhaler is that the bag can easily be turned inside out, and thoroughly cleansed after every case.

The Ormsby's inhaler, or one of its modern modifications, consists of a metal face-piece fitted with an air-cushion, and containing a small opening through which air can pass both to and from the patient. This opening is covered by a metal cap; by rotating which, the air supply can be increased or diminished at will. To the end of the face-piece opposite to the air-cushion is attached a wire framework, over which the neck of an india-rubber bag is stretched, the bag itself lying free. It is most important that this bag should be large: many inhalers are sold with a bag which is too small to hold a complete expiration, and the strain of breathing into such a bag during a prolonged administration throws a heavy burden on the respiration. A sponge is inserted into the neck of the inhaler, and on to this sponge the ether has to be poured. Before commencing the inhalation, this sponge should be wrung out in warm water; as, if dry, it will not absorb the ether: and care must be taken that it fills up loosely the whole of the aperture,

FIG. 18.—Ormsby's Ether Inhaler.

so that the patient must breathe entirely *through* the sponge and not *round* it. This apparatus has one drawback, and that is not a serious one, viz., anæsthesia cannot be *induced* by ether with it: and this is why general practitioners usually prefer the Clover's regulating inhaler. But though induction by ether is impossible (or rather, not to be recommended), and up till a few years ago necessitated a special gas apparatus, this second apparatus is no longer essential ; as a small quantity of ethyl chloride sprayed into the Ormsby's inhaler will induce anæsthesia even better than nitrous oxide, and the administration can afterwards be continued by ether in the same instrument.

Before ether inhalation, the patient must always be thoroughly prepared, as detailed in Chapter IV. ; and should be lying down if possible, though the recumbent posture is not essential. If it be decided to induce anæsthesia by means of nitrous oxide gas, the ether inhaler must first be charged with 1 oz. or 1½ oz. of ether (the amount varying according to the type of the patient), because there will be no time to pour in the ether after the patient is unconscious. The Ormsby must now be placed somewhere close at hand, with the mouth directed upwards and the air-slot wide open ; in this position scarcely any ether vapour will escape, as the vapour is heavier than air. Now, anæsthesia must be produced by means of nitrous oxide gas, in exactly the same manner as though a dental operation were about to be performed. When the patient is fully under the influence of the gas, as described in the preceding chapter, the gas apparatus is removed from the face *at the end of an inspiration*, and instantly replaced by the charged Ormsby's inhaler, so that the succeeding expiration is received into the Ormsby. The next few breaths that the patient takes will therefore consist of air, ether, and the nitrous oxide gas that he has exhaled.

When this change of apparatus is first made, the ether inhaler must not fit the face too closely, and the air-slot must be fully open, otherwise spasm of the larynx will occur. If, however, the breathing continues fairly well, the pressure should be gradually increased until the inhaler thoroughly fits; and then the air-slot must also be closed little by little until full surgical anæsthesia is obtained, the symptoms of which have been described in the latter part of Chapter III.

From this time onwards, about half an ounce of ether will be required to be poured on to the sponge every ten minutes in an average case; an alcoholic subject would, of course, require more. The air-slot may now be opened again slightly. As a rule, this can be kept open about one-eighth of an inch for the remainder of the operation, but the actual amount must depend upon the symptoms. Some anæsthetists prefer to keep this air-slot always closed, and to give a breath of air by taking the inhaler completely off the patient's face after about every sixth breath.

To induce anæsthesia by means of ethyl chloride, we may either administer both the ethyl chloride and the ether in the same inhaler; or, as some prefer, the ethyl chloride may be given in a separate apparatus, which is replaced by the Ormsby's inhaler containing ether after the patient has lost consciousness. The former method is obviously the simpler, and I think it is quite as good as the latter.

Everything being ready, about 3 cc. to 5 cc. of ethyl chloride (the dose depending upon the physique of the patient) are sprayed on to the sponge of the Ormsby, and the latter is at once placed over the patient's face and made to fit accurately. The air-slot is kept closed, and no air should be admitted until anæsthesia is complete. Very occasionally, marked spasm of the glottis necessitates the temporary removal of the inhaler; but in the vast majority of cases, the breathing will become quite free and deep after the first two or three breaths. When full anæsthesia has been induced, the apparatus is removed from the face, and 1 oz. or $1\frac{1}{2}$ oz. of ether poured on the sponge; the air-slot is opened to its full extent, and the apparatus gently reapplied to the patient's face. There is no need for hurry in this instance, because ethyl chloride produces a deeper and more prolonged anæsthesia than nitrous oxide does. Usually there is no interruption in the respiration after the change; and the air-slot can be gradually closed in a few seconds. The patient is ready for operation in about two or two and a half minutes from the commencement of the inhalation.

Some anæsthetists object to this method, because some of the ethyl chloride remains on the sponge when the ether is added; but though I fully acknowledge the fact, I have never seen the slightest ill-effects occur in consequence.

The other method of administering the ethyl chloride—ether sequence requires a second inhaler. In this case, an ounce or more of ether may be poured on to the sponge of the Ormsby's inhaler beforehand, as was done in the case of the administration of "gas and ether." The ethyl chloride is then poured into a removable graduated glass tube (A, fig. 19), and this tube is attached by means of a small piece of rubber tubing (B), to the stopcock (C) at the bottom of the bag. Between the bag and the face-piece there is a two-way stopcock, the handle of which (E) can be placed as shown in the figure; under which circumstances the contents of the bag are shut off from the face-piece, and an air-hole (F) opened; or the handle may be drawn forwards, by which movement the air-hole is closed, and the entrance to the bag opened. The inhaler is applied to the patient's face with the ethyl chloride in the tube (A), and the air-hole (F) open. When the patient is accustomed to the apparatus, the handle (E) is manœuvred in such a way as to let the patient nearly fill the bag with his expira-

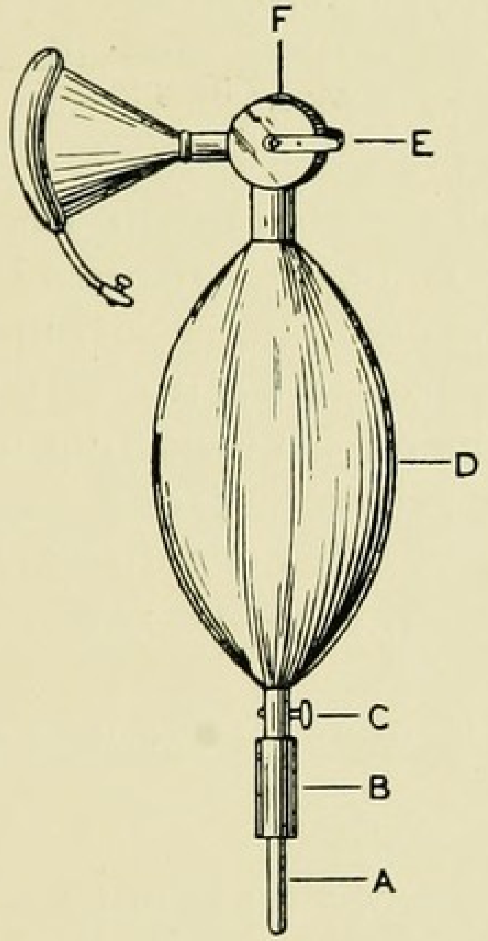

FIG. 19.—Ethyl Chloride Inhaler.

tions; and then it is left in the position that allows to and fro breathing. The tube (A) is now tilted, so as to pour a portion of its contents into the bag; and after one or two breaths of this *weak* ethyl chloride vapour have been breathed, the remainder of the ethyl chloride in the tube is emptied into the bag. This will produce anæsthesia in about twenty or thirty seconds;

at the end of which time, this apparatus is laid aside, and the Ormsby's inhaler, charged with ether, is gently applied to the patient's face at the end of an inspiration, so that his next expiration will fill, or partly fill, the bag of the Ormsby. The administration from this point onwards is the same as mentioned above.

The advantages claimed for this method are :—

(1) That the ethyl chloride is given gradually instead of the full dose being presented all at once, thereby lessening the risk of spasmodic closure of the larynx.

(2) That no more ethyl chloride is breathed by the patient after the change to ether has been made.

On the other hand, the necessity for using two inhalers instead of only one is an objection worthy of some consideration ; and the bag of the inhaler shown in fig. 19 cannot be turned inside out for cleaning.

The ethyl chloride—ether sequence, in whichever way it is administered, has certain advantages over the nitrous oxide—ether sequence ; the chief of which are :—

(1) Induction is more rapid, usually from two to three minutes.

(2) There is no cyanosis.

(3) There is less secretion of mucus.

(4) Laryngeal spasm and coughing are less common when the ether is substituted.

(5) Struggling during the early stages is rare.

During the use of Ormsby's inhaler, the sponge may occasionally freeze owing to the evaporation of the ether : if this should happen, the sponge should be removed and wrung out in warm water, and replaced. Fresh ether must then be added, and the administration proceeded with. For certain elderly and obese patients it is sometimes not advisable to commence the administration with either nitrous oxide gas or ethyl chloride, though it may be desirable to employ ether during the operation. In such cases, the C.E. mixture should be used in a Rendle's mask until the struggling stage is just commencing, and then the mixture should be laid aside, and the administration continued with ether in an Ormsby's inhaler, as above; except that the air-inlet should not be closed quite so quickly, on account of the chloroform which is still being expired. The pressure required to make this inhaler fit the face accurately tends to force back the lower jaw. This effect must be counteracted by holding the inhaler with one hand, and supporting the jaw just behind the angle with the other. A better method, because it leaves the anæsthetist with one hand always free, is to hook his little finger round the angle of the jaw, while he holds the inhaler with the thumb and index finger of the same hand. With practice, the little finger soon becomes strong enough to keep the jaw well forward in all but the most difficult cases.

The Clover's portable regulating inhaler (fig. 20), consists of a face-piece, a rotating metal ether chamber, and an india-rubber bag. The only part requiring special description is the ether chamber. This consists of a complete sphere of metal (B), one-half of which is hidden from view by a cover (A) of the same material. This forms a jacket, and contains some water, the object of which is to prevent the ether in the spherical part from becoming too cold. Through the middle of the whole runs a metal cylinder (E), about which the sphere rotates; and during this rotation certain openings in the inside of the sphere and in the cylinder are caused to more or less correspond in position, by which means the proportion of the air passing from the bag to the face-piece, either directly along the cylinder or through the ether chamber, can be made to vary. This proportion is demonstrated by a scale on the chamber, marked "0," "1," "2," "3," and "F," around which a pointer (D) rotates. When the latter points to "0," the air passes directly along the cylinder from the face-piece to the

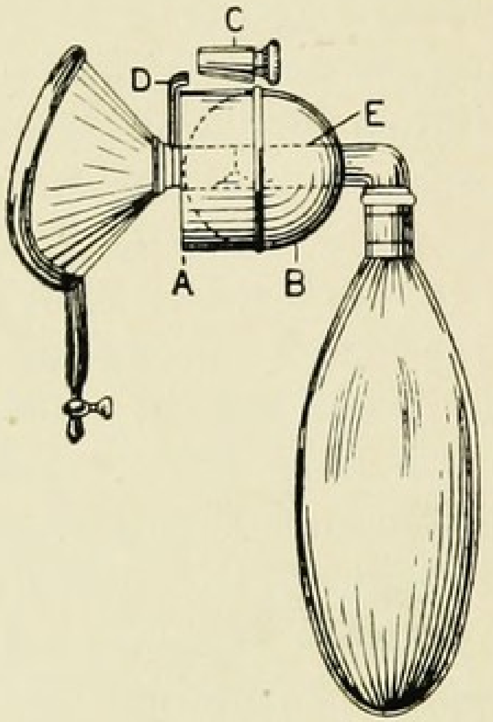

FIG. 20.—Diagram of Clover's Portable Ether Inhaler.

bag and *vice-versa*, without entering the ether chamber. When it points to "1," three parts of the air pass direct, while one part passes over the ether. When the mark "2" is reached, one-half of the air passes each way. At "3," three parts of the air enter the ether chamber, while only one part goes direct; and finally when the pointer reaches "F" (meaning *Full*), the whole of the air traverses the ether chamber, the passage along the central cylinder (E) being entirely blocked.

With this apparatus, ether may be administered from the commencement of the inhalation, or it may be preceded by nitrous oxide gas or ethyl chloride. To induce anæsthesia by means of ether, first turn the indicator to "1," remove the stopper, and pour $1\frac{1}{2}$ oz. of ether into the inhaler; replace the stopper and turn the indicator back to "0." It is well now to blow through the apparatus to get rid of any smell of ether. Next attach the bag, and a face-piece of a size to fit the patient.

All being ready, the patient's head is turned to one side and the face-piece applied to his face. He should be told to breathe through the mouth, as the irritating effect of the ether vapour on the nasal mucous membrane is thereby avoided. During the first four or five breaths, no ether should be turned on; but at the end of this time, the indicator should be *very slowly but continuously* turned towards "1" on the scale, about one minute being occupied in proceeding thus far. A second minute is occupied in reaching "2," and a third in reaching "3." Should any holding of the breath occur, the increase must be made more slowly; and if the patient cough, the indicator must be temporarily moved backwards a little to lessen the strength of the ether vapour. Movements, on the other hand, would indicate the necessity for pressing the induction more quickly. It is not usually requisite to pass on to "F," except when anæsthetising powerful men or alcoholics.

With this method, some degree of cyanosis is practically essential, especially in the earlier stages; and in this respect the Ormsby's inhaler is superior to the Clover. During induction the face-piece must be removed from the face to admit one breath of air after about every fifteen breaths; but as time goes on, a breath of fresh air may be allowed more frequently, according to the condition of the patient. Dr. Hewitt[1] has devised an apparatus on the principle of this inhaler, but differing from it in having a larger air-way, which he says is "of advantage in lessening the initial unpleasant sensations of re-breathing, and in reducing the asphyxial phenomena (stertor, cyanosis, and laboured breathing) of well-established ether anæsthesia."

If the weather be cold, the inhaler should be stood in warm water for five minutes before commencing the administration; after which the ether chamber of the inhaler must be carefully emptied of water before the ether is put into it. It is also beneficial to envelope as much of the metal part of the apparatus as possible with the hands throughout the administration, to prevent too much cooling. A *charged* ether inhaler must of course never be placed near a fire to warm it; otherwise an explosion is likely to occur.

After the first $1\frac{1}{2}$ oz. of ether, which was placed in the inhaler before the administration was commenced, has been used up, the stopper must be removed, and another ounce poured in; the indicator at the time standing anywhere except at "0," so that air may escape through the inhaler while the ether is being poured in. After a fresh supply has been furnished, the indicator should be placed rather nearer to "0"

[1] Hewitt's "Anæsthetics," p. 278.

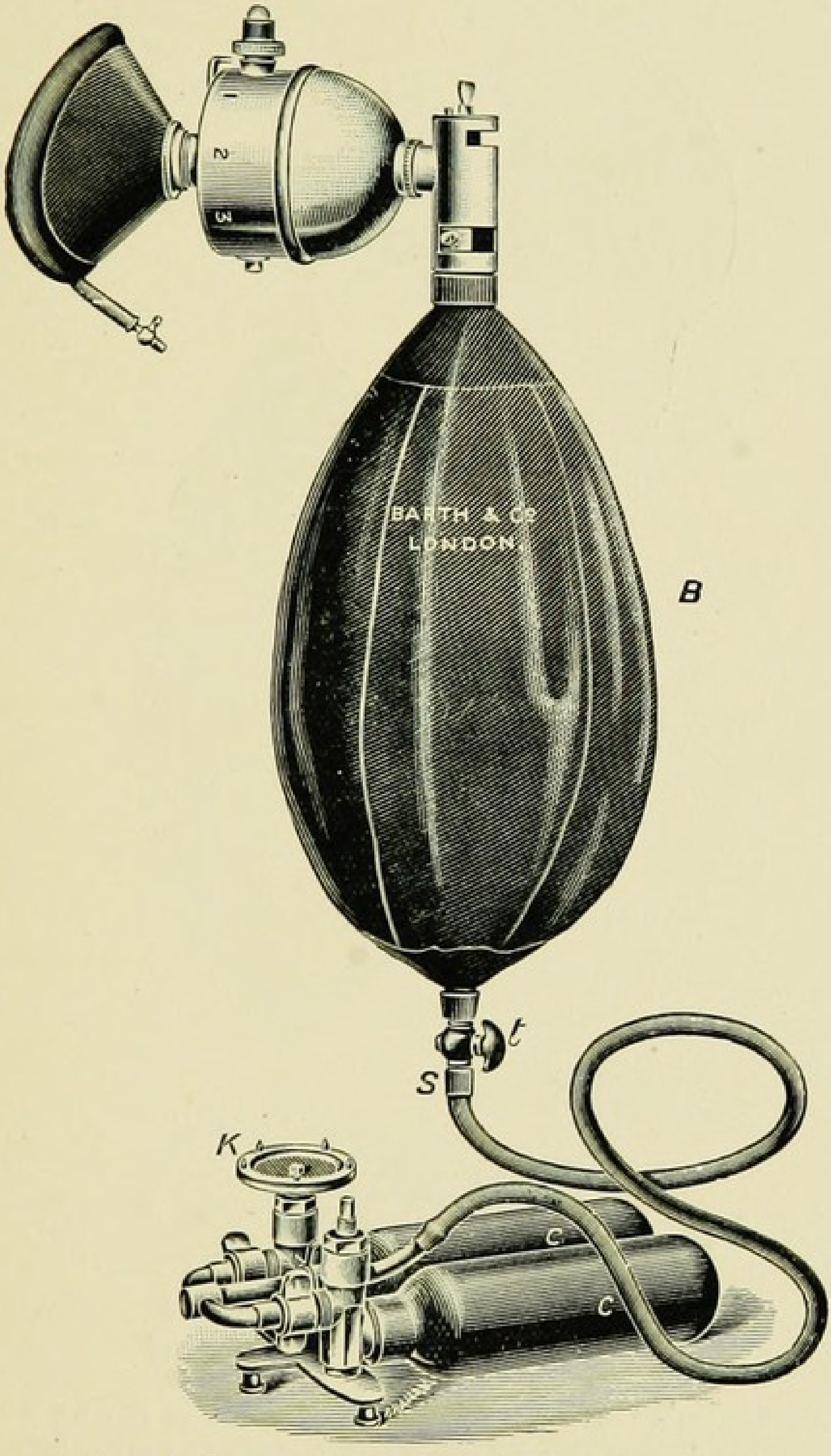

FIG. 21.—Clover's Portable Ether Inhaler fitted to a Hewitt's Nitrous Oxide Apparatus for administering "gas and ether."

for the first few breaths than it has been during the rest of the administration.

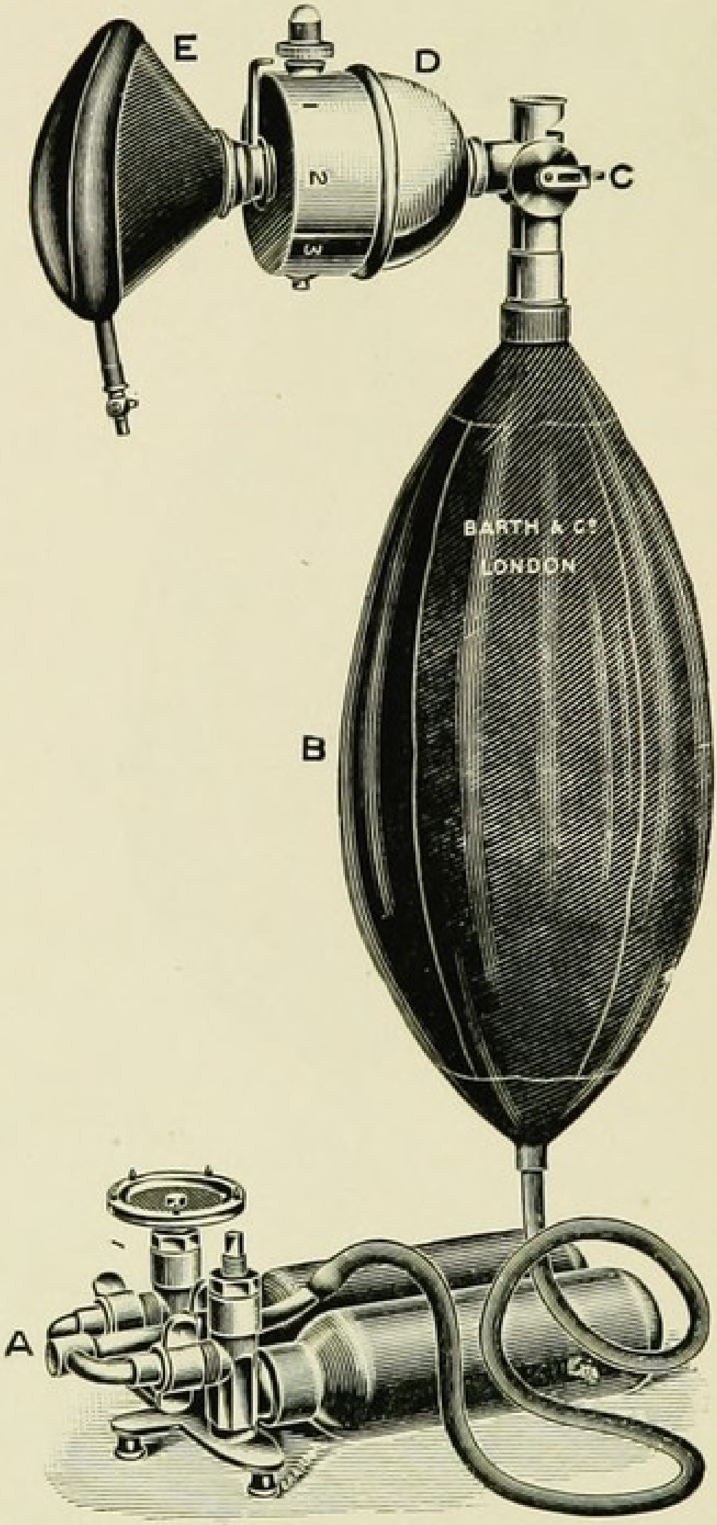

FIG. 22.—Clover's Portable Ether Inhaler fitted to a Barth's Nitrous Oxide Apparatus for administering "gas and ether."

In order to precede ether by nitrous oxide gas with this inhaler, the latter should be charged with $1\frac{1}{2}$ oz. of ether as already mentioned, and a face-piece attached; but instead of now fixing on the small bag belonging to the inhaler, an ordinary nitrous oxide bag (with stop-cock) is affixed. Fig. 21 shows a Hewitt's gas apparatus attached to the Clover; and fig. 22 shows a Barth's apparatus similarly attached. In either case the gas-bag is two-thirds filled with nitrous oxide gas from the bottles, and the stopcock set so as to allow the patient to breathe air in and out through the apparatus, the ether indicator being placed at "0." After a few breaths like this, the stopcock is turned so as to shut off the air-inlet, and to admit the nitrous oxide gas to the patient, whilst the exhalations escape through the expiratory valve. Fig. 22 shows the apparatus at this stage. After the patient has taken about twelve breaths in this way, the valves are reversed so as to permit "to and fro" breathing into the bag, and at the same time the ether chamber is rotated a little to admit a small quantity of ether vapour to mix with the gas. The rotation of the ether chamber is continued more quickly than when ether alone is given from the commencement. The gas-bag and stopcock are now disconnected, and replaced by the small bag belonging to the ether apparatus, after which the inhalation continues in the same way as when gas is not being employed. One strong objection to this method is that the re-breathing of ether vapour into the nitrous oxide apparatus makes the latter smell of ether; and all future patients who require nitrous oxide gas only will be nauseated by the very unpleasant smell of stale ether.

If it be desired to induce the anæsthesia with ethyl chloride instead of nitrous oxide gas, either a separate inhaler may be used for the ethyl chloride, as is sometimes done in the case of the Ormsby method; or the ether chamber may be charged as before with ether, and the indicator placed at "o." Then 3 cc. or 5 cc. of ethyl chloride are sprayed into the small rubber bag, which is then fitted quickly to the apparatus, and the whole applied at once to the patient's face. Unconsciousness is rapidly produced, and the indicator may be turned directly to "1," or even further, and in a short time it may be rotated to "3" or "F," as desired.

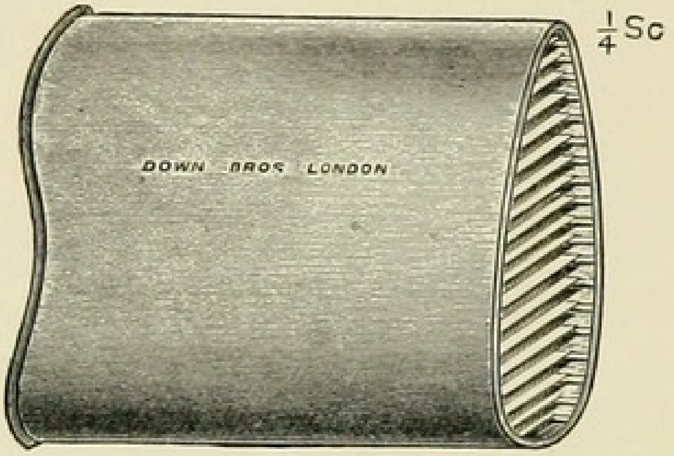

FIG. 23.—Allis's Ether Inhaler.

Up to the present, all the methods described for administering ether have required a bag into which the patient breathes and re-breathes; but there are certain cases in which this bag is omitted. In the case of feeble children, as stated in the early part of Chapter V., ether may sometimes be administered from a lint cone or Skinner's mask, or even under exceptional circumstances, from a Junker's inhaler. Again, in the case of weak adults, especially if very obese and old, or suffering from severe shock, during an administration of the C.E. mixture in a Rendle's mask (fig. 31), the breathing may become so feeble that it is found necessary to continue the anæsthesia by means of ether in this same mask. In America, the Allis's inhaler (fig. 23) is almost exclusively used, in which the air passes freely through between the layers of a folded bandage on to which the ether is poured. The excitement stage is unduly prolonged by this method, and an enormous quantity of ether is required, especially if the patient be robust or alcoholic; and the atmosphere of the room must sometimes become quite intolerable. In certain cases, however, this method is very useful.

Rectal Etherization has been tried by Molière, Buxton, and others, for operations upon the mouth. But the dangers attending the method are too great to entice most anæsthetists to employ it.

Once the administrator has learnt from practice how to overcome the difficulties of the early stages of etherization, he will find that ether is not merely the safest, but also the most satisfactory anæsthetic for most prolonged surgical operations; and it will cause him far less worry and anxiety during the administration than chloroform will. With ether, as a rule, everybody in the room can hear at once if any change takes place in the breathing; whereas with chloroform the breathing is frequently inaudible, and so shallow that it is often only with difficulty that the anæsthetist himself can tell whether the patient is breathing or not at any given moment. Induction of anæsthesia, moreover, can be brought about by means of ether in one-third of the time that is required when chloroform is employed, and with much less excitement and struggling. The objectionable smell and taste of the ether can be avoided by preceding it with either nitrous oxide gas or ethyl chloride; and the after-sickness, though it occurs more frequently as the result of ether, is not usually so severe as that which occurs after chloroform. "Ether tremors" are hardly worthy of being called an objection to ether, as they can easily be controlled, either by pressing the administration, or by a temporary change to chloroform. Excessive secretion of mucus and saliva, however, is more important, and may occasionally lead to considerable difficulty; but even this depends largely on the way the ether is given: if it be administered steadily and progressively in the early stages, with not too much air-limitation, and if an *even degree of anæsthesia* be afterwards maintained, this secretion will seldom cause serious trouble. When it does occur, an early change to chloroform should be made, without waiting till the patient's lungs are almost completely blocked. This excessive secretion and cyanosis are less common when an Ormsby's inhaler is used than when a Clover is employed; indeed, with the Ormsby's inhaler, the patient need hardly ever be blue at all. Many surgeons think that etherization is incompatible with an abdominal operation; but this is entirely wrong. If sufficient ether be given, and the air-way be kept perfectly free, I think an abdominal operation rather indicates than contraindicates the use of ether: but a deeper anæsthesia is necessary. The pupils must be at least semi-dilated, and the corneal reflex must be abolished. If the abdominal movements be too great with this depth of anæsthesia, it can be corrected in almost every case, either by pulling the jaw more forward, and perhaps placing a dental prop between the teeth, or by admitting air more freely, under which circumstances more ether must be poured into the inhaler: the Ormsby's pattern should be used. When an extremely deep anæsthesia is required, ether is the only drug that is at all safe; whereas in a light degree of anæsthesia, reflex difficulties connected with the heart and respiration are far less likely to occur with ether than with chloroform; and if they do occur, they will be less dangerous. I am here referring entirely to the average and healthy patient.

Cardiac failure is very rare during ether narcosis; respiration usually fails some considerable time before the circulation: but Mr. Braine and Mr. Gardner have each met with one case of sudden syncope during its use, of which the first-mentioned recovered. Such cases seem impossible to explain or prevent, but fortunately they are exceedingly rare. In both cases a thoroughly reliable make of ether was used, and one of the cases at least was perfectly healthy. Mr. Foy also quotes a case in the *Lancet* of August 29, 1891, of a healthy woman, aged 41, who died from cardiac syncope during an administration of ether for the removal of uterine fibroids.

In the majority of cases, if ether be employed, a deeper anæsthesia should be maintained than with chloroform; but the depth of the anæsthesia, as well as the choice of the drug, must depend upon the condition of the patient and the requirements of the operation. Moreover, the depth of anæsthesia suitable at one period of an operation may be quite unsuitable, and sometimes absolutely unsafe, at another period of the same case.

The special dangers attending etherization and the after-effects will be discussed in a later chapter.

The three chief difficulties which students seem to find when administering ether are :—

(1) To make the face-piece fit ;

(2) To give a breath of air at the proper moment ;

(3) To keep the jaw forward.

It is absolutely impossible to obtain the best results with nitrous oxide gas, ethyl chloride, or ether, unless the face-piece fits accurately. The place where leakage is most likely to occur is at the groove on each side of the nose ; but when a Clover's inhaler is being used, the mere weight of the apparatus tends to draw the face-piece away from the uppermost cheek. Watchfulness and a certain amount of energy are alone required to prevent this leakage in the vast majority of cases ; and the same remark applies to the pulling forward of the lower jaw. In some patients, especially those of the bull-necked type, considerable effort is required to keep the jaw well forward ; and when the operation is a long one, the strain becomes very fatiguing. It is, however, absolutely essential, and a good anæsthesia can never be obtained unless it be persisted in.

The giving of a breath of air at the right moment appears to be extraordinarily difficult to many beginners, and nothing but practising the movement a number of times will teach them. When a breath of air is to be allowed, the inhaler must be removed completely from the patient's face immediately after an expiration, so that a full breath of air is inhaled ; then the face-piece must be instantly replaced, so as to catch the whole of the following expiration (containing the fresh breath of air) in the bag. This appears very simple and obvious on paper, but it is wonderful how difficult it seems to be to a beginner.

When ether is being administered, special care should be taken to keep up the body temperature of the patient; and the air of the theatre and of the recovery room should be warm, as the evaporation of the ether from the lungs causes considerable cooling. Probably the so-called "ether pneumonia" would be almost unknown if patients, after undergoing operations, were placed in a special ward leading directly out of the operating theatre for twenty-four hours; the temperature of this ward being maintained at a few degrees only below that of the theatre. This matter will be further considered in the chapter dealing with "After-effects and Their Treatment."

CHAPTER VIII.

THE ADMINISTRATION OF CHLOROFORM.

THERE are a great many methods and inhalers for the administration of chloroform, some very simple, and some exceedingly complicated: by some of the latter methods a definite percentage vapour can be presented to the patient, and the anæsthetist has the satisfaction of knowing exactly how much chloroform the patient is receiving; but this does not materially help the patient; for, just as some people are violently purged by a dose of calomel which will even fail to act as a mild laxative in other patients, so also some patients require a dose of chloroform which would kill others. No method of administering chloroform is free from danger, the occurrence of which depends rather upon the experience and watchfulness of the administrator than on the method chosen.

There are, of course, exceptions in special cases, but the general rule in the matter of chloroform administration seems to be the same as in most other things, viz., the best method is the simplest. The great popularity of chloroform amongst general practitioners is certainly due largely to the fact that the only thing required for its administration is a bottle of chloroform. His inhaler will consist of a handkerchief, towel, or serviette, which can be borrowed at the patient's house; or, if he take an inhaler with him, it will probably be a Skinner's or Schimmelbusch's mask. His desire is to obtain the best possible anæsthesia, and not merely to have the satisfaction of knowing that he is employing a mixture of 2 or $1\frac{1}{2}$, or even 1 per cent. of chloroform vapour in air.

If a towel be chosen, a satisfactory mask can be made by drawing one corner of it through a large safety pin. A piece of lint, preferably doubled, and fixed with a safety pin, is the form of inhaler used almost exclusively at the Hospital for Sick Children, Great Ormond Street. If properly shaped it is ex-

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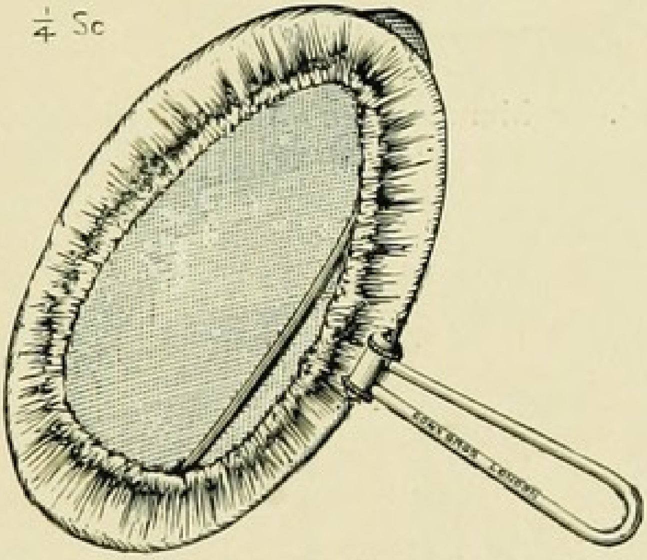

FIG. 24.—Skinner's Chloroform Mask.

cellent, and it has the advantages of being clean and cheap : a fresh one is used for every case, and if one gets soiled during an administration, it can be thrown away and a new one used. The Skinner's mask (fig. 24) consists of a piece of flannel kept in shape by means of a wire frame, which can be folded up. An improvement on this mask is that bearing the name of Schimmelbusch, and is shown in fig. 25. A fresh piece of lint is inserted for every case ; and there is no fear of burning the patient's face with the chloroform, as any excess of the drug poured on the lint is caught by a metal trough. In using any of the other open methods, great care must be taken not to allow the mask to rest against the patient's face, otherwise a painful burn may result.

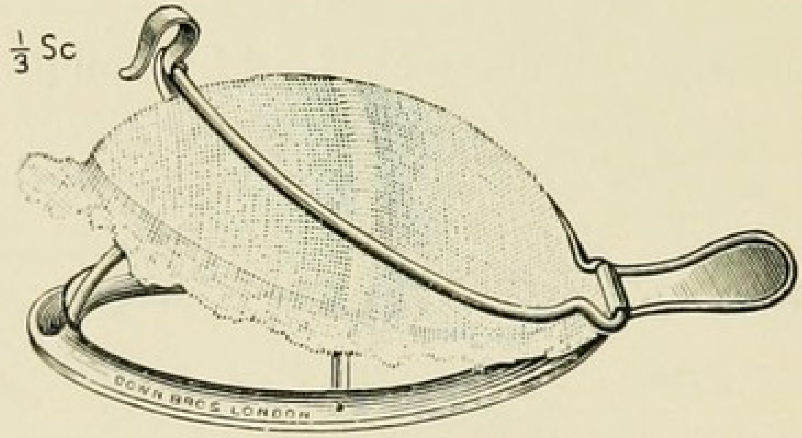

FIG. 25.—Schimmelbusch's Chloroform Mask.

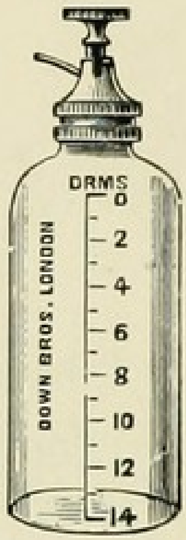

FIG. 26.—Thomas's Drop-bottle for Chloroform or the C.E. Mixture.

Thomas's drop-bottle (fig. 26) will be found to be the most convenient form of bottle for dropping the chloroform on to the mask. It is fitted with a spring valve which can be fixed so that no chloroform can escape, or in a second position which allows the chloroform to run out. There is also a third position in which the top of the stopper can be depressed by means of the forefinger, which allows the chloroform to escape; and when the pressure of the finger is removed the opening is closed by a spring.

When administering chloroform by the **Open Method,** that is by means of the drop-bottle, and either a Skinner's or a Schimmelbusch's mask, or on a towel, handkerchief, or piece of lint, the anæsthetist must not attempt to induce anæsthesia in two or three minutes, as he may, and indeed should, do when using ether. He should always commence with a *weak* vapour, and occupy at least five or six minutes in inducing anæsthesia by means of chloroform; but, on the other hand, the induction must not be too slow, otherwise syncope may occur in connection with impending vomiting, though the vomiting itself may not take place. The induction may be commenced in one of two ways: either pour about a drachm of chloroform on to the mask, and hold the latter several inches vertically above the patient's face. If there be no coughing or catching of the breath, the mask may be brought gradually nearer to the face with each breath. The second plan is to place the mask close over the nose and mouth, and let one or two drops of chloroform fall on it; then one or two more drops after a breath or two, and so on until anæsthesia is complete. Whichever method be chosen the results are practically the same. The vapour must at first be very dilute, and its strength gradually but progressively increased. Whether the initial dilution be obtained by putting a small quantity of chloroform on to the inhaler, or by holding the inhaler some distance away from the mouth, does not signify. The patient should be told to close his eyes, otherwise the vapour will make them smart.

If sufficiently dilute, chloroform vapour is sweet and pleasant to inhale ; any coughing or holding of the breath means that the vapour is too strong, and the mask should be raised a little further from the patient's mouth, but not altogether removed. But so long as these symptoms do not occur, and the breathing continues free and regular, the sooner the anæsthesia can be induced the better. The chloroform must be given continuously ; and as the vapour is heavier than air, the mask must always be held *vertically above* the patient's mouth : it is quite useless to hold it *in front of* the mouth when the head is turned to one side. Likewise, if a more or less dilute vapour be required at any given moment, this alteration must be made by raising or lowering the mask in a vertical direction. Any such changes in the strength of the vapour should be made gradually, and the entire removal of the mask from the patient's face during induction is inadvisable, if not actually dangerous.[1]

Though, during the induction stage, the strength of the vapour should usually be steadily and gradually increased, an exception to this rule must be made when struggling occurs. Owing to the longer time occupied in inducing anæsthesia by means of chloroform than by ether, the excitement stage is often more marked when the former drug is used ; and this is the most dangerous period of chloroform anæsthesia, as explained in Chapter XI. Most of the sudden deaths which occur in the early stages of chloroformization

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[1] Kirk, *Lancet*, August 29, 1891, p. 512.

can be accounted for as there stated. The way to guard against such a calamity is to give a continuous, and not too strong, vapour from the commencement of the inhalation, so as to avoid struggling as far as possible; and secondly, if struggling occurs, the chloroform mask should be raised a little further from the face; and when the deep inspiration is taken at the end of the fighting, the mask should be entirely removed for the one breath. As this fighting is naturally more vigorous in muscular men than in weaker subjects, so we find that the apparently strong and healthy are actually more liable to die suddenly in the early stages of chloroform anæsthesia than are the feeble and delicate individuals, whose hold on life seems less secure.

The same rule applies to children as to adults; but in children, especially those of the fat, flabby type, who have been fed on patent foods instead of milk, the excitement stage sometimes does not occur at all, and is replaced by a condition resembling sleep, which is termed "*false anæsthesia.*" This state usually results from the use of a too dilute chloroform vapour. The child is credited with being very good, because it does not cry or move, but breathes regularly and quietly, until apparently it is ready for the operation to commence; that is to say, the respiration becomes regular and shallow (really, too shallow), the pupils are small, and the corneal reflex abolished. The light reflex, however, is also absent, in spite of the smallness of the pupil. If an incision be now made, the child will move, and very likely cry, and the reflexes will be found to have become brisk. Sudden fatal cardiac syncope is said to occur sometimes when an incision is made in this state. There are various ways of preventing the occurrence of this annoying, and perhaps dangerous, condition. One is to give a stronger vapour from the commencement; a second plan is to pinch the child to make it cry and breathe more deeply; but the best method in my opinion is to anæsthetize the child with a mixture of equal parts of chloroform and ether on an open mask, instead of with chloroform. The mixture will cause deeper breathing, and will thereby prevent "false anæsthesia" occurring. If, however, plain chloroform has been employed, and this state has supervened, it is sometimes difficult to obtain a true anæsthesia, because the breathing is so shallow that very little chloroform is absorbed. Sometimes, but not always, rubbing the lips briskly with a rough towel will cause the respiration to become deeper, and so more chloroform will enter the system. An easy method is to remove the mask for a time until the child commences to come round, when the respiration will become deeper of itself; and then a more concentrated dose of chloroform may be administered. But the best method is to saturate the mask with plain ether; which will soon stimulate the breathing, and then the anæsthesia can be continued either with the C.E. mixture, or with chloroform if preferred. One other method which may be mentioned, is to compress the chest a few times whilst still holding the chloroform mask over the face: in this way more of the vapour will be absorbed, and a deeper narcosis will supervene. Dastre points out that chloroform considerably diminishes the force of expiration, while inspiration is only slightly modified: hence, it is the expiratory movements that need to be assisted.

So many junior administrators like to depend solely upon *one* sign of anæsthesia, that I think a word of warning should be delivered here. When chloroform is administered by the open method, the lid-reflex is sometimes abolished before surgical anæsthesia has been produced; and this is especially the case with children. It is probably due to a local anæsthetic effect upon the eyes.

When complete anæsthesia has been obtained, and the operation commenced, the most difficult part of the anæsthetist's work is over, except in exceptional cases. His chief duties now are to maintain the anæsthesia at an even depth, and to keep the respiration free from any embarrassment, which is especially difficult in the case of fat and bull-necked individuals. Cyanosis must never be permitted during chloroform anæsthesia: when ether is being administered, a certain amount of cyanosis, though better avoided, does not really matter very much; but with choloform, any asphyxiation at all adds considerably to the risks of the administration. The pulse which, as we have seen, is of practically no importance during etherization, should be felt from time to time while chloroform is being administered. It should be regular and of about normal frequency: a very slow pulse would indicate that the anæsthesia was too deep, and that the vapour should be more diluted with air. It must be remembered that when the circulation becomes feeble, the blood passes more slowly through the capillaries in the lungs, and hence absorbs a larger quantity of the chloroform than when the current is more rapid. Except for the first incision, a lighter anæsthesia may be maintained when giving chloroform than when giving ether; the pupils should be kept smaller, but not too small, and the lid-reflex may generally be allowed to be present, though it should be sluggish. If, however, too light a degree of anæsthesia be aimed at, inconvenient and perhaps dangerous reflex interference with the respiration is liable to occur, especially in children; and personally, unless there be some special reason for not doing so, I prefer to maintain a deep anæsthesia throughout; that is to say, to

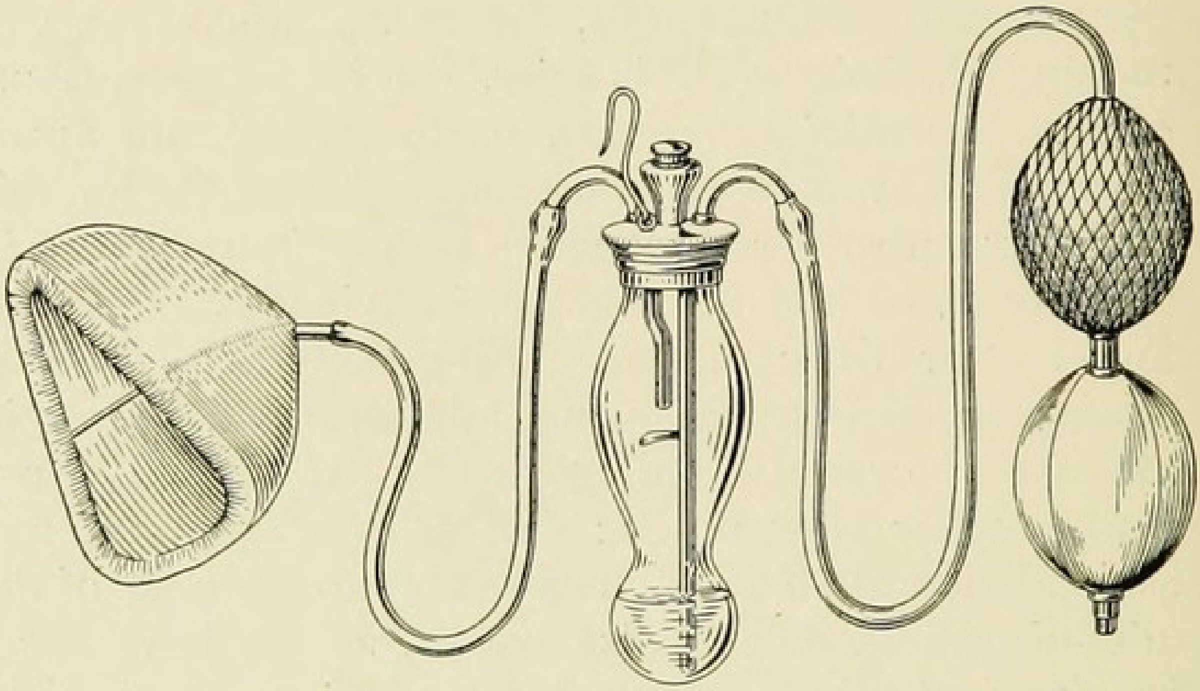

FIG. 27.—Braine's modification of Junker's Apparatus fitted with a flannel mask.

keep the eyes fixed and moist, but with no overflowing of tears, and the lid-reflex absent. Under such circumstances the pupil will be nearly semi-dilated, and the light-reflex will be present but sluggish. But for practitioners who only administer anæsthetics occasionally, it is perhaps safer to use a lighter anæsthesia.

Instead of using the simple methods mentioned above for giving chloroform, some administrators prefer to employ one of the modifications of Junker's inhaler (fig. 27). No useful purpose would be served by describing the original form of this inhaler as designed by Junker, though it is still mentioned in the catalogues of some instrument makers. Various small details distinguish different forms of the apparatus, but in general it may be said to consist of a glass bottle graduated at its lower extremity up to 1 oz. or $1\frac{1}{2}$ oz. Into this bottle run two metal tubes, either separately or one inside the other : one of these passes almost to the bottom of the bottle, while the other stops about half-way down. To the upper end of the longer tube is attached a hand-bellows, with the intervention of a convenient length of rubber tubing. When chloroform is in the bottle, air is forced through it by means of the the bellows and the longer (afferent) metal tube ; and the air, which thus becomes laden with chloroform vapour, is forced out of the bottle through the shorter (efferent) metal tube, to the upper end of which is attached another piece of rubber tubing, to convey the chloroform-laden air to the face-piece, as shown in fig. 27, or to a mouth-tube. The face-piece should consist of a wire frame with flannel stretched over it, so that air can enter through it as well as all around it. To the top of the bottle is attached a hook, by which it can be hung from the administrator's button-hole or pocket. To use this apparatus about an ounce of chloroform (or C.E. mixture) is placed in the bottle and the tubes attached. Great care must be paid to the fixing of the tubes ; and before using the apparatus on a patient, the anæsthetist should always compress the bellows to make sure that the tubes are not reversed ; for should this be the case, a spray of liquid chloroform would be driven into the patient's face or throat, and this accident has caused death in more than one case. The face-piece is now placed over the patient's face, but no chloroform is administered until all nervous holding of the breath or very rapid breathing ceases. Then the ball, which is held in the right hand, is compressed to the slightest possible extent with the thumb, during the brief interval between an expiration and the following inspiration. This moment is chosen so that the chloroform-laden air will be the first portion of the air inspired, and will, therefore, be the portion which will reach the lungs. If the compression be made a moment later the portion of the air which contains the chloro-

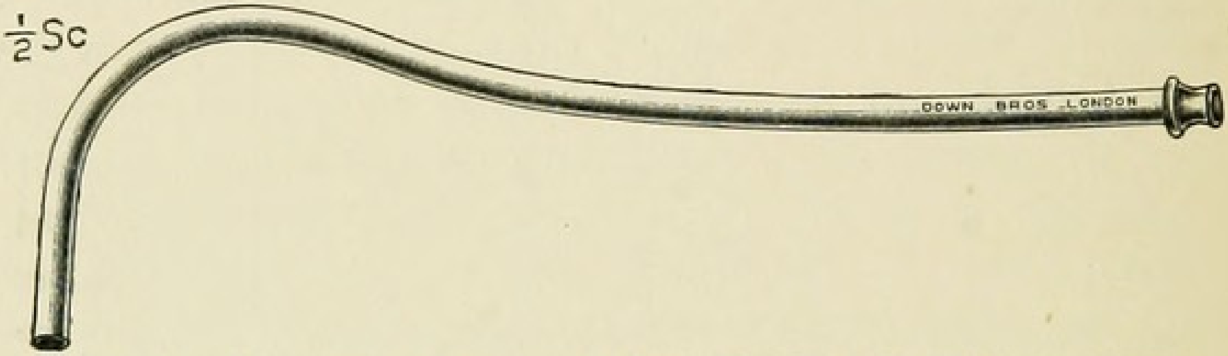

FIG. 28.—Mouth-tube for use with Junker's Chloroform Inhaler during Mouth Operations.

form vapour will remain in the bronchi or trachea, and not reach the lungs at all.

These compressions of the ball-bellows must be continued after *every* expiration, and not intermittently. Moreover, during the induction stage the compressions must be very gradually increased in amplitude from the smallest possible at the commencement, to a complete compression after about five minutes. After anæsthesia is fully induced, it is seldom necessary to compress the ball more than half its full extent with each breath; but the amount must depend upon the requirements of the case.

For mouth and nose operations, the flannel mask must be removed, and a mouth-tube (fig. 28) attached in its place. The inhalation may be begun with the apparatus, as shown in fig. 27, or with an ordinary Skinner's mask until the operation is about to commence, after which the anæsthesia must be maintained by means of the Junker with a mouth-tube, the orifice of which should be held just at the opening of the mouth when the patient is an adult, or about 3 or 4 in. above the mouth and pointing towards the latter, if the patient be a child. Some prefer to use a soft catheter instead of the mouth-tube, and to pass it through the nose until the distal end just reaches the posterior border of the soft palate; but this is not such a clean method as the mouth-tube, though it has the advantage of retaining its position without being held, and consequently leaving the anæsthetist with one of his hands free. With the same idea, various combinations of gag and mouth-tube have been devised; but these also are difficult (or impossible) to clean, and are liable to become blocked by clots of blood and discharges from the mouth. Instead of a ball, which requires a hand to work it, a foot-bellows may be attached to the afferent tube of the inhaler. The anæsthetist's right hand is thereby left free, which must be a great advantage, especially when the operator's assistant is not accustomed to mouth cases; but it seems doubtful whether one could control the compressions with one's foot to such a degree of nicety as with the hand.

For operations within or near the mouth or nose, a Junker's inhaler is practically essential; but apart from such cases, it is probably not so good as a simple open mask, with which the death-rate is no higher, if so high: and the working of a Junker is liable to remove a certain amount of the anæsthetist's attention from his patient, as well as giving him a false sense of security. When a Junker is being employed, it is necessary to remember that the same compression of the ball will not always cause the evaporation of the same amount of chloroform by the air passing through the inhaler. The amount absorbed depends upon the temperature; thus, supposing a full compression of the ball to drive 60 cc. of air through the chloroform, we find that at a temperature of 60° F., 1 minim of chloroform will be taken up by it, while at a temperature of 70° F., 1·2 minim of chloroform will evaporate; and at a temperature of 80° F., 1·5 minim is absorbed by the same quantity of air. Further, it is not merely the temperature of the operating room that affects the amount of absorption, for the chloroform itself cools considerably during the administration, owing to the evaporation which is taking place; and if a mixture of chloroform with ether be employed in the inhaler (and still more with plain ether), this cooling will be much greater than is the case with chloroform, for the amount of ether which evaporates with each compression of the ball is about six times greater than that of chloroform.

It is reckoned that 4 per cent. of chloroform vapour in the air respired will induce anæsthesia in *any* subject, and that more than 5 per cent. is highly dangerous. In ordinary cases, 3 per cent. or 3·5 per cent. is sufficient. After anæsthesia has been once induced, it can be maintained by a 2 per cent. or even 1 per cent. mixture of chloroform vapour and air. There are some who consider that even during induction the strength of the mixture should never be greater than 2 per cent. or 2·5 per cent.; and Mr. Vernon Harcourt has devised a most ingenious inhaler, shown in fig. 29, by the use of which the exact percentage of chloroform vapour in the air breathed

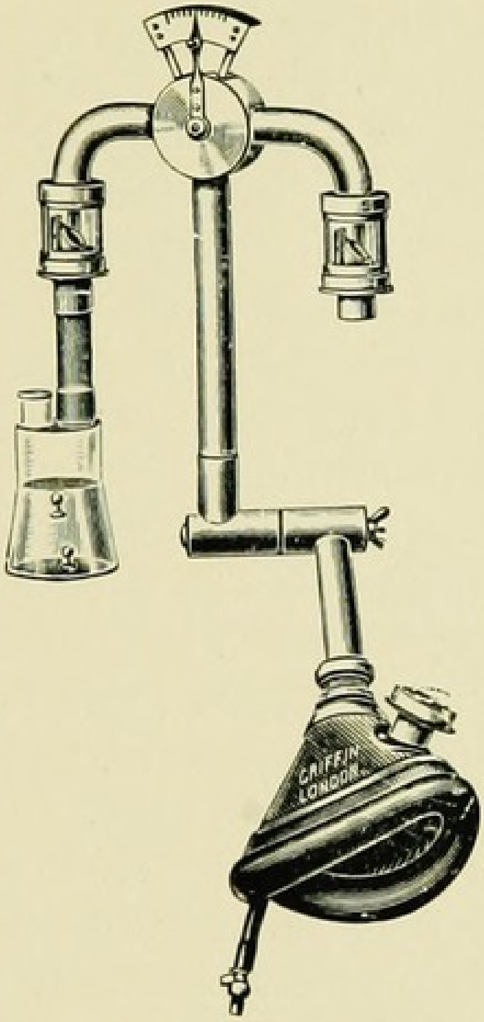

FIG. 29.—Vernon Harcourt's Apparatus for administering Chloroform by the Dosimetric Method.

can be regulated and known by a dial at the upper part of the instrument. Those who approve of this apparatus claim that, when it is used, they know exactly how much chloroform they are administering at any given moment. But, if with an open mask and a drop-bottle we obtain the same degree of anæsthesia as they do when they give a 1·5 per cent. mixture with this inhaler, it stands to reason that we must be giving a 1·5 per cent. mixture from our open mask; and, inasmuch as they are bound to alter their percentage according to the symptoms shown by the patient, it would seem that there is very little, if anything, gained by having such a complicated, though mathematically accurate, piece of mechanism. It is true that no deaths have yet occurred with this instrument; but as it has only been used, so far as I am aware, by a few expert anæsthetists, it is more than likely that the patients so anæsthetized would not have died even if a Skinner's mask had been employed. Further, though there have been no deaths, there have been cases in which artificial respiration has been required to save the patient's life. When this apparatus is used, great care must be taken to avoid the slightest shaking of the bottle; for when the indicator points to 2 per cent. of chloroform vapour, this percentage will be suddenly raised from 2 per cent. to 7 per cent. or 8 per cent., if the surface of the chloroform becomes agitated. Induction by this method is tedious, an average adult patient requiring fifteen minutes or longer, and alcoholic subjects are almost impossible to put under with the small percentage of vapour yielded by this inhaler.

Depth of Anæsthesia Required.—Up to the present I have not dealt with the special signs of anæsthesia met with during the use of chloroform, because administrators differ greatly in their ideas of which reflexes should be kept and which abolished in an ordinary case. Some consider that a deep anæsthesia is accompanied by more shock than a light anæsthesia, while others hold the exactly opposite opinion, and say that during a light narcosis sudden reflex cardiac inhibition may take place. It is at least certain that the patient should be sufficiently deeply under the influence of the drug to prevent interference with free breathing by commencing retching or vomiting, or by muscular spasm. On the whole, I think a light chloroform anæsthesia is less satisfactory than a deep one for an average case presenting no special indications. The symptoms that would indicate that too much chloroform was being given are :—dilated pupils with fixed and dry eyes, absence of the corneal and light reflexes, flaccidity of the general muscular system, and weak respiration. The colour of the face is dusky, and the pulse at the same time will be found to be feeble, slow, and perhaps irregular.

Dilatation of the pupil taken by itself is not necessarily a sign of profound narcosis, as it also occurs when the patient is "coming round," but in this case it would be accompanied by lachrymation, movements of the ocular globes, light-reflex and a lid-reflex. In this case, also, the respiration will become weak, and it may be hampered by swallowing movements; which, together with pallor of the face, would indicate the near approach of vomiting. Expiration may be accompanied by a vocal sound, but this does not occur so constantly with chloroform as with ether. Sometimes the pupil, instead of being dilated, is *very* small, and accompanied by a good colour of the face, very shallow breathing, and perhaps a slight lid-reflex. These symptoms also indicate that the anæsthesia is not sufficiently deep; and unless care be taken, vomiting may be the first sign of returning consciousness to be noticed ; the pupil will then dilate suddenly, but too late to prevent the occurrence.

It is not advisable to make a patient fast for too long before he takes chloroform, otherwise he will be faint, and liable to an attack of syncope during the administration. This is especially important when the patient is a child.

The patient who is about to inhale chloroform should avoid any exertion beforehand, and he should be placed in the recumbent position, with the head low and turned to one side.

CHAPTER IX.

THE ADMINISTRATION OF ETHYL CHLORIDE.

THE uses of this drug are somewhat similar in kind to those of nitrous oxide; that is to say, it can be employed as an anæsthetic throughout a short operation, or as a preliminary to ether. Some have also used it as a preliminary to chloroform, but there seems to be little advantage in such a procedure. When used by itself it is not suitable for operations which are likely to last longer than ten minutes, or in which absolute relaxation of the muscles is essential. The anæsthesia produced by a single dose of ethyl chloride is about double or treble as long as that obtained by a single application of nitrous oxide gas; and this superiority is specially noticeable in the case of young children, who give such a short and generally unsatisfactory anæsthesia with nitrous oxide. It has a further advantage over the latter substance in being more portable, and requiring no complicated or special apparatus for its administration. On the other hand, the after-effects of ethyl chloride are more frequent and more severe than those of nitrous oxide gas.

Fig. 30 shows a tube of ethyl chloride prepared by Messrs. Duncan and Flockhart, containing 60 c.c. of the drug, which is sufficient to anæsthetize about twelve or fifteen average patients, allowing for a certain amount of waste. When required for use, this tube should be held vertically with the nozzle downwards and inserted well inside the inhaler. The required

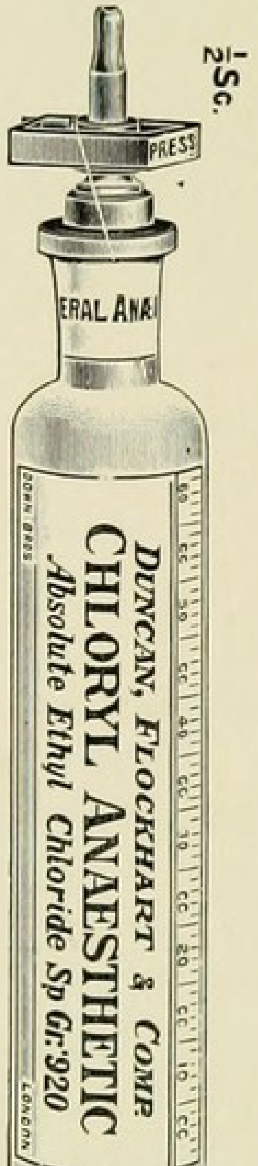

FIG. 30.—Tube of Ethyl Chloride fitted with Stopcock for General Anæsthesia.

dose is then released by pressing on the valve where it is marked "press," with the thumb.

In order to ensure a good and tranquil anæsthesia a closed inhaler is essential; in a few cases I have tried giving the drug by the semi-open method, in a Rendle's mask, but the results were not satisfactory. The simplest inhaler from which to administer ethyl chloride is an Ormsby's ether inhaler (fig. 18), with the sponge removed.

The patient should fast for at least four hours previous to taking the drug, and must always be made to pass his water just before the administration. He may then either sit up in a chair or lie down, according to the requirements of the operation; and the clothing about the neck and waist must be loosened. He should be allowed to assume a comfortable position, with the head in a straight line with the body. After-sickness seems to be less likely to occur when the administration has been conducted with the patient in the recumbent posture than in the sitting position. All being in readiness, the mouth should be examined for foreign bodies, &c., and a dental prop inserted. The required dose of ethyl chloride, which varies from 3 cc. to 5 cc., according to the age and physique of the patient, is then sprayed into the bag of the Ormsby's inhaler, and the latter must be immediately applied to the patient's face, all air being rigidly excluded, except what was in the patient's chest at the commencement of the administration. The patient should be instructed to breathe freely and deeply through the mouth; for as soon as two or three breaths have been thus taken, all the initial discomfort of the inhalation passes away, and the sensations of the patient are the same as those experienced during the early stages of nitrous oxide anæsthesia, except that unconsciousness supervenes much more rapidly, and quite suddenly. It will, however, occasionally happen that the patient cannot take these two or three breaths, owing to spasmodic closure of the larynx, under which circumstances it may be essential to allow one full inspiration of air. But if air be unnecessarily permitted, or if too much air be given owing to the inhaler not fitting the face thoroughly, excitement and struggling are sure to result, and the anæsthesia obtained will not be satisfactory. In order to obviate the possibility of laryngeal spasm, the inhaler shown in fig. 19 may be employed, by means of which the dose can be given more gradually. The method of using this inhaler is described in Chapter VII. Another very simple apparatus for the administration of ethyl chloride is the bag of a Clover's ether inhaler fitted directly on to a face-piece, without the intervention of the metal ether chamber. In this case the required dose is sprayed into the bag in the same way as when an Ormsby's inhaler is used, and the administration conducted on the same principles.

When inhaling ethyl chloride there is a feeling of giddiness and tingling after the first or second breath, with tinnitus aurium; and after about ten breaths consciousness is entirely lost. Deep anæsthesia is obtained after about fifteen or eighteen breaths, and its occurrence may be recognised by the supervention of deep regular breathing of rather greater frequency than normal, and accompanied by some stertor: the eyes become fixed, and usually turn downwards; the pupils dilate, and the lid-reflex is abolished. The pulse is practically unaltered, and there is no cyanosis or jactitation; the face, indeed, is usually flushed. The muscular system is generally quite flaccid, unless too large a dose has been administered, or the inhaler has been kept on the face too long when there may be rigidity and opisthotonos. Occasionally the muscles are spasmodically contracted in the position of tetany.

The signs upon the appearance of which the operation should be stopped are the same as in the case of nitrous oxide gas ; but there is little fear of the patient feeling the latter part of the operation, as there is a short but distinct period of analgesia after the apparent return to consciousness. The eyeballs first roll slowly from side to side ; their movements then gradually become more purposeful, until the eyes regain their normal look of intelligence. Swallowing occurs for some little time before the patient becomes conscious, and it is therefore important to throw the head forward as soon as the operation is finished, in order that blood can run out of the mouth ; for if swallowed, it is likely to cause vomiting. Hearing is the first special sense to return, and it is therefore advisable not to indulge in any conversation until the patient is quite sensible. Next to hearing, the sense of sight returns ; but it is still some few seconds before the patient becomes really cognizant of his surroundings.

Children are the best subjects for ethyl chloride, whereas they give a short and usually unsatisfactory anæsthesia under nitrous oxide gas. They lose consciousness and become quiet in about ten seconds, and give an available anæsthesia of a minute to a minute and a half : their colour remains normal, and there is no screaming during the operation. Alcoholics and heavy smokers are liable to struggle with considerable vigour shortly before they regain consciousness. The average length of quiet working anæsthesia is about 80 seconds after a single administration, but sometimes it is much longer. If more time be required, a fresh dose can be sprayed into the inhaler, and the latter reapplied to the patient's face as soon as the first signs of returning consciousness appear.

If, however, an anæsthesia lasting from five to ten minutes be required, the administration should be commenced as indicated above, but as soon as full anæsthesia has been obtained a breath of air should be given, and the inhaler reapplied. After this, a breath of air should be allowed after about every six inspirations from the bag; and from time to time, as necessity requires, a fresh dose of about 2 c.c. of ethyl chloride must be sprayed into the inhaler. There are other methods of increasing the duration of the anæsthesia, which are at times very useful, but are not advisable unless the administrator has had a large experience with the drug.

CHAPTER X.

MIXTURES AND SEQUENCES.

THE object of the majority of anæsthetic mixtures is to diminish the danger of chloroform administration by reducing the strength of the vapour and by counteracting its depressing effects on the circulation. They are of special use for anæsthetizing young children and elderly and obese subjects; and also for many cases of pulmonary and cardiac disease, especially if fatty degeneration of the heart be suspected.

Mixtures of alcohol with chloroform have been used in various proportions, but the most popular one at the present time consists of chloroform containing 10 per cent. by volume of alcohol (A_1C_9). This mixture should be administered in drops on a Skinner's mask, in precisely the same way as though plain chloroform were being given. The effects also are the same, except that the breathing and pulse do not become quite so feeble.

The best known of all the chloroform mixtures is the **A.C.E. Mixture,** which consists of one part of alcohol, two parts of chloroform, and three parts of ether. These proportions of the three drugs are chosen so as to obtain a mixture which volatilizes uniformly. It should, nevertheless, always be freshly mixed for each case. This mixture, like all mixtures containing chloroform, must never be administered from a closed inhaler. A Rendle's mask as modified by Silk (fig. 31) is the most suitable appliance for

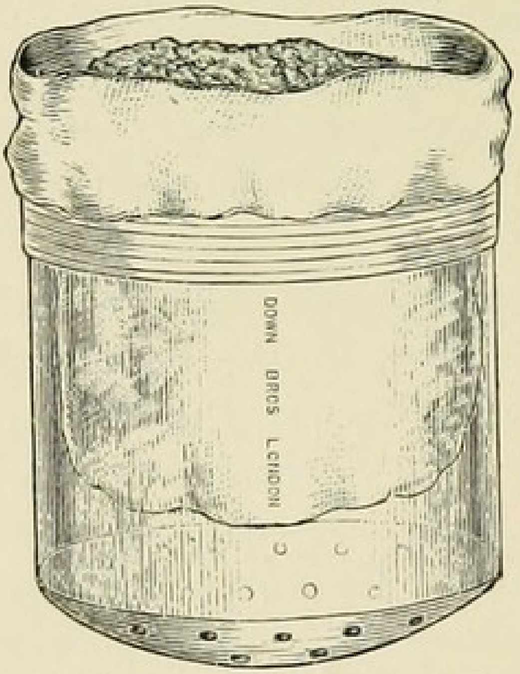

FIG. 31.—Rendle's Mask for administering the C.E. or A.C.E. mixture.

its use. This consists of a celluloid mask with numerous holes bored through its closed end : it is lined by flannel, and has a sponge upon which the mixture is to be poured. The latter should be in a Thomas's drop-bottle (fig. 26) of a larger size than the usual chloroform one; as by this means additions of the mixture can be made during the early stages through the holes at the top of the mask without removing it from the face.

To induce anæsthesia by this means, about half a drachm of the mixture should be poured on to the sponge of the inhaler, and the latter held about 3 in. above the patient's face. If the breathing continue regular, the mask is gradually brought nearer until it rests on the face; and then more of the mixture must be added from time to time through the holes in the top until full anæsthesia is produced. After this it is better to make all further additions directly on to the sponge, otherwise the flannel will get wet, and may burn the face. About seven or eight minutes should be occupied in inducing anæsthesia by this means. The effects of the mixture are what would be expected with chloroform, with the addition of the stimulating effects of the alcohol and ether: that is to say, we obtain the usual signs of a chloroform anæsthesia, but the respiration is deeper, and the pulse rather fuller and quicker.

Many anæsthetists now use a mixture of chloroform and ether in the same proportions as in the A.C.E. mixture, but without the alcohol. This C_2E_3 mixture is administered in precisely the same manner as stated above, and the symptoms are the same. In hospitals, where many of the anæsthetics are given by junior residents, it is safer to employ a weaker mixture, and for this purpose a mixture containing one part of chloroform with two parts of ether (C_1E_2) will be found more satisfactory. Having been anæsthetized myself by this method on one occasion, I found a great objection to it. The ether in the mixture decomposes the celluloid, with the result that the patient has a very unpleasant taste of camphor for a day or two afterwards.

For anæsthetizing children, I have for some years employed the C.E. mixture almost exclusively. Chloroform is not at all a safe or satisfactory drug to administer to these subjects. The actual strength of the mixture must depend on the age and condition of the child: infants give the best results with C_1E_2; but older children, unless very feeble, usually require a stronger mixture, and for them I mix up equal parts of chloroform and ether (C_1E_1). Whichever mixture is used, it should be administered precisely as though plain unadulterated chloroform were being given. A Skinner's mask or lint cone should be employed, and the mixture poured on to it gradually and steadily from a drop-bottle. The state of "false anæsthesia," which occurs frequently in these subjects as the result of chloroform, is never met with when the mixture is employed; and reflex interference with the respiration or circulation is not nearly so likely to arise; and should it do so, it is less dangerous. The mixture may often be employed in a Junker's inhaler during mouth operations; but in this case the proportion of chloroform will of course gradually increase as the operation proceeds, owing to the greater volatility of ether: but in spite of this fact, young infants give better results with the mixture than with chloroform alone.

Before leaving the subject of "mixtures," a few words may be said concerning **Somnoform.** This is a mixture of 60 per cent. ethyl chloride, 35 per cent. methyl chloride, and 5 per cent. ethyl bromide. It was introduced about eight years ago by Drs. Rolland and Field Robinson, of Bordeaux, and has been employed in an enormous number of cases considering the short time it has been on the market. It came into disfavour, however, partly on account of the way in which it was advertised, and partly on account of its being a proprietary article. But on the other hand, had it not been for the booming of somnoform, we should probably not be using ethyl chloride as a general anæsthetic in the present day. I experimented largely with somnoform when it first came into existence, and published my results in the *British Dental Journal* of May, 1903. These results I have since compared with those that can now be obtained by means of pure ethyl chloride; and I find that the dose required, and the induction period with the two drugs are practically the same; but the resulting anæsthesia was slightly more prolonged and rather quieter when somnoform was used, at least with children. On the other hand, after-sickness was more common, and the smell of the ethyl bromide was very unpleasant. As regards safety, I do not think there is any difference, though Hewitt considers that the pure ethyl chloride is somewhat safer. My chief reasons for ceasing to employ somnoform were its unpleasant smell due to the ethyl bromide, and the fact that I noticed that some bottles of the mixture did not give quite the same results as others—in other words, the mixture was not constant. It was at least as good as, or better than, most of the *foreign* makes of ethyl chloride at the present time. The mode of its administration is the same as that of ethyl chloride.

In addition to mixing two or more anæsthetic drugs together, it is frequently necessary, or at least advisable, to use them in sequence. The nitrous oxide — ether sequence, the ethyl chloride — ether sequence, and the C.E.—ether sequence have been considered in Chapter VII. In addition to these, there are many others. The details of the chloroform—ether sequence would be the same as those of the C.E.—ether sequence, with the exception that the chloroform is administered on a Skinner's frame instead of in a Rendle's mask. The change to ether in either case should be made at the moment when struggling commences.

A very important sequence is the gas (or ethyl chloride)—ether—chloroform sequence, and this is one of the most frequently used of all. The change from ether to chloroform may be intended from the commencement, as in operations within or about the mouth or nose. It may, on the other hand, become necessary during an operation, on account of excessive secretion of saliva and mucus, cyanosis, or failure to obtain a satisfactory result with ether. For these latter cases, no definite rules can be laid down: each case must be treated according to the symptoms, but if a change become necessary, it should not be delayed so long that no satisfactory narcosis can possibly be obtained with any anæsthetic. In the case of mouth operations, &c., where it is intended from the outset to change from ether to chloroform, the patient should be put under in the ordinary way with gas and ether, or ethyl chloride and ether, until full surgical anæsthesia is reached. The inhaler should then be put aside, and the corneal reflex allowed to return, and any cyanosis that may be present should be allowed to pass off; then chloroform must be sprinkled, very slowly at first, upon a Schimmelbusch's mask, or other suitable open inhaler. The strength of the vapour must now be gradually increased until full surgical anæsthesia again supervenes, when the operation may commence. If the operation be upon the mouth or nose, the change from the Schimmelbusch's mask to the Junker with a mouth tube may be made when the surgeon is about to commence the operation: it is better not to make this change until the gag is inserted.

Under this same heading I will include the use of morphia or cocaine combined with general anæsthetics. If ether is to be administered, neither of these drugs should be employed; but in brain and spinal operations, and sometimes in certain other cases, an injection of morphia before chloroform anæsthesia has been strongly advocated, especially by surgeons, on account of its action in lessening vascularity. Anæsthetists find that it increases their difficulties, as it alters some of the signs by which we recognise the degree of anæsthesia. Thus, the pupil will remain small whether the patient be in the second, third, or fourth stage. On the Continent, this combined method of morphia and chloroform anæsthesia is very popular. Dastre[1] states that the preliminary dose of morphia markedly diminishes the violence of the excitement stage, which is of special importance in alcoholic subjects; and that it also lessens the danger of laryngo-reflex syncope, by suppressing laryngeal irritation. If morphia is to be given, about one-sixth of a grain should be injected hypodermically half an hour before the time of the operation; and then anæsthesia should be induced by means of chloroform until the patient is fully under, after which only just enough chloroform should be administered to insure tranquillity. Unless great care be taken, the breathing is liable to cease; and the special susceptibility of certain patients to morphia must always be remembered. The addition of atropine to the morphia has been advised by some, in order to prevent vagus inhibition of the heart, but it has not proved of special advantage in practice.

[1] Dastre, "Les Anesthésiques," p. 235.

Cocaine is sometimes employed in conjunction with chloroform, especially for ophthalmic operations. In these cases the mixed anæsthesia is of great use, because a very deep degree of narcosis is otherwise required; and this is more than usually dangerous when the eye-signs are not available as guides. A drop of a 2 per cent. solution of cocaine put into the eye a minute or so before the commencement of the administration of chloroform, and another drop when consciousness is abolished, will considerably lighten the task of the anæsthetist. In throat surgery also the addition of cocaine is useful. In this case, a spray should be used shortly before the administration commences, and it may be resorted to again during the operation if required. The cocaine makes no difference to the ordinary signs of anæsthesia, nor does it add to the risk of the chloroform as morphia does: but its own special dangers in certain subjects must not be forgotten.

CHAPTER XI.

DIFFICULTIES AND DANGERS OF GENERAL ANÆSTHESIA, AND THEIR TREATMENT.

I.—Respiratory Troubles.

STOPPAGE of the respiration during anæsthesia may be :—(1) Obstructive ; (2) Spasmodic ; (3) Paralytic.

(1) **Obstruction** may be caused by tight clothing or bands around the neck, chest, or abdomen ; or by the impaction of a foreign body in the upper air-passages. These have been considered in the chapter dealing with the preparation of the patient. Other causes of obstructed respiration are the falling back of the tongue; the entrance of blood, mucus, and pus into the larynx ; swelling of the tissues in or about the upper air passages ; altered relation of the parts ; and pressure or encroachment on the chest cavity. The most frequent cause of obstruction is the falling back, or the spasmodic drawing back, of the tongue ; and this must be corrected by pressing forward the lower jaw from behind the angle ; or, if necessary, by inserting a gag, and pulling the tongue well out of the mouth by means of tongue-forceps. The best form of gag for this purpose is Fergusson's (fig. 11), as this can be worked with one hand, while the ordinary Mason's gag requires a second hand to fix

the screw. As regards tongue-forceps, the usual ring tongue-forceps are shown in fig. 32. This form, however, is not good, as it is liable to slip, and it crushes such a large surface of the tongue that the latter is

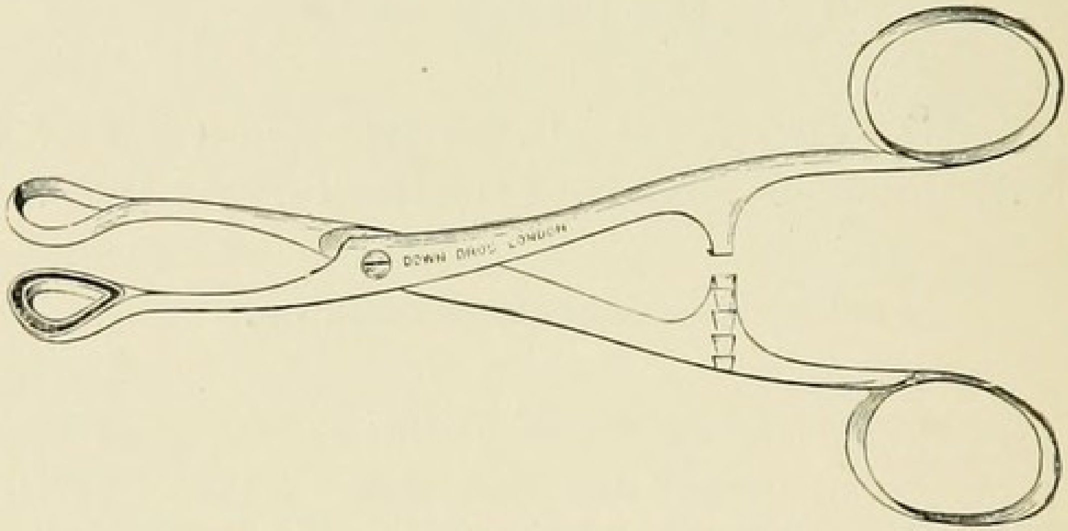

FIG. 32.—Ring tongue-forceps.

painful for several days afterwards. The Berger's tongue forceps, shown in fig. 33, has not these disadvantages. Two small spikes pierce the tongue, leaving very little, if any, soreness; and they cannot

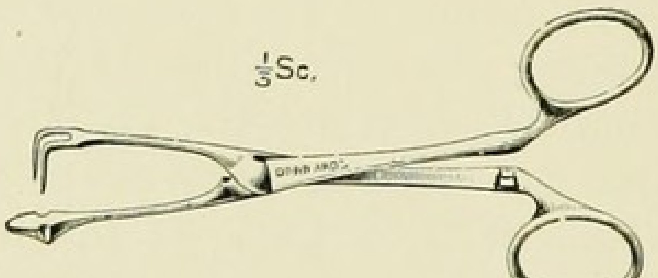

FIG. 33.—Berger's tongue-forceps.

slip. Mr. Braine has designed a pair of tongue forceps, shown in fig. 34, the blades of which are flattened, and form a wedge when closed. They can, therefore, be inserted between the clenched teeth, and used as a mouth-opener first, and then as an ordinary pair of tongue-forceps afterwards.

During operations within the mouth or nose, *blood* or *pus* will obstruct the breathing unless the throat be frequently sponged out. Sometimes a post-pharyngeal abscess will burst during the induction of anæsthesia : hence, in these cases, it is well to insert a small dental prop or some form of gag between the teeth before commencing the administration ; and the head must be turned well over to one side, so that, should the abscess burst, the pus will escape from the mouth instead of being inhaled : these same precautions

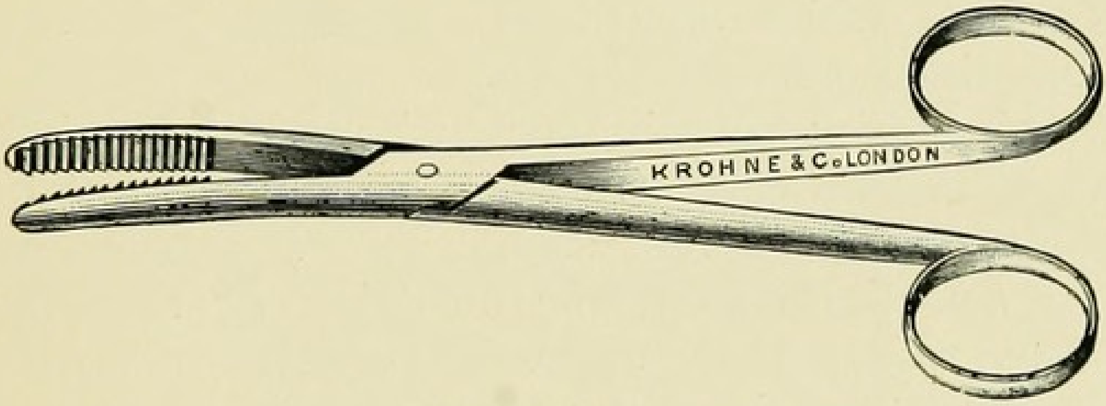

FIG. 34.—Braine's Tongue-Forceps.

should also be taken in cases of persistent vomiting. Obstruction is sometimes caused by the excessive secretion of mucus and saliva due to ether. This should be corrected by changing to chloroform before it is too late, and if the excessive secretion continue the throat must be sponged out and the head kept turned to one side so that some of the mucus at least can run out of the mouth. Sponging should be avoided as far as possible, as it tends to increase the secretion of mucus, and also makes the throat very sore afterwards.

Swelling of the tissues in or about the upper air-passages will not cause obstruction in normal cases; but in cases of large goitre, cellulitis of the neck, tumours of the larynx, aneurysm, and in cases where there is any swelling which causes even slight or occasional dyspnœa before the administration, all bag inhalers must be avoided; as the congestion that they cause will increase the swelling, and therefore also the obstruction. Chloroform alone is suitable for such patients, and nitrous oxide gas is particularly dangerous. Should the breathing cease, it may not be possible to relieve the symptoms even by tracheotomy, as the obstruction may be too low down. These are the cases in which almost all of the deaths under nitrous oxide gas have occurred.

Altered position may interfere with the respiration, especially in such cases as empyema, if the patient be turned on to the sound side. The Trendelenburg posture sometimes stops the breathing by throwing the whole weight of the abdominal contents upon the diaphragm. The lithotomy position may also cause difficulty from the thighs pressing on the abdomen. But the most common cases in which obstruction occurs from this cause are dental cases, when the operator presses down upon the lower jaw, or forces back the tongue during the removal of a difficult tooth. In such cases the anæsthetist must carefully watch his patient, and from time to time tell the operator to allow the patient a breath of air. He should also make counter-pressure upon the lower jaw from below.

Pressure or encroachment on the chest cavity may be due to the surgeon or his assistants leaning on the chest, or to the weight of the patient's uppermost arm when he is lying in the lateral position, and finally to abdominal distension, or a collection of fluid in the pleura or pericardium.

A minor degree of obstruction may be caused by the *clenching of the teeth*. If the teeth be in a perfect condition and fit accurately, it is advisable to place a small prop between them before commencing the administration, otherwise it may be very difficult to separate them later. Should spasm of the masseters arise when no prop has been inserted, the teeth must be forced apart by a wedge, as shown in fig. 35, until there is room to insert a gag, care being taken not to break the teeth.

(2) **Spasmodic** cessation of the breathing may arise in two different ways : either *spasm of the larynx* may

FIG. 35.—Wedge-shaped Mouth-opener.

occur from too strong a vapour being employed ; and this may take place at the very commencement of an administration of ethyl chloride, ether, or chloroform, or it may happen during light anæsthesia whenever a fresh dose of the drug is added. The treatment of such a condition would be to temporarily remove the mask a little from the face and re-apply it more gradually. Spasm of the larynx may also be produced by the presence of mucus, blood, or any foreign body in the larynx ; and the condition is also met with as a result of a reflex action due to the performance of an operation during an insufficiently profound anæsthesia. The treatment in this latter case would be to very carefully press the administration; whereas, if the spasm be due to the presence of mucus, blood, or pus within the larynx, the patient must be permitted to regain his coughing reflex, and then the throat should be sponged out. Inversion of the patient will often assist the process. If these remedies fail, tracheotomy must be performed.

The second spasmodic trouble is *spasm of the chest muscles* during the struggling stage, and this is a serious condition, as we can do so little to relieve it. The chest becomes fixed in a position of complete expiration, and no method of performing artificial respiration will cause it to expand. We are therefore entirely dependent upon reflex action in response to such stimuli as brisk rubbing of the lips and traction upon the tongue.

(3) **Paralytic** respiratory failure occurs during deep anæsthesia, and is due to an overdose. Should this occur, the anæsthetist's duty is to stop the administration and to keep a clear air-way by opening the mouth with a gag and drawing out the tongue with forceps; and then performing, or superintending the performance of, artificial respiration, which must be commenced without any delay, and continued until natural breathing is re-established. Rubbing the lips briskly with a towel will often prevent the breathing from quite stopping, if it be practised soon enough; and if this fail, rhythmic traction on the tongue may be tried. But if the breathing has entirely stopped, nothing but artificial respiration is of any use. Simple compressions of the chest may suffice, and should always be tried first; for, as Dastre has pointed out in the

case of chloroform, the force of expiration is considerably diminished, while inspiration is but little modified. Hence, if we assist the expirations, we can do all that is required in most cases without interrupting the operation.

If, however, natural breathing does not recommence almost immediately, the operation must be stopped without further delay, a sterilized towel placed over the wound, and artificial respiration performed by one of the recognized methods. Before describing these in

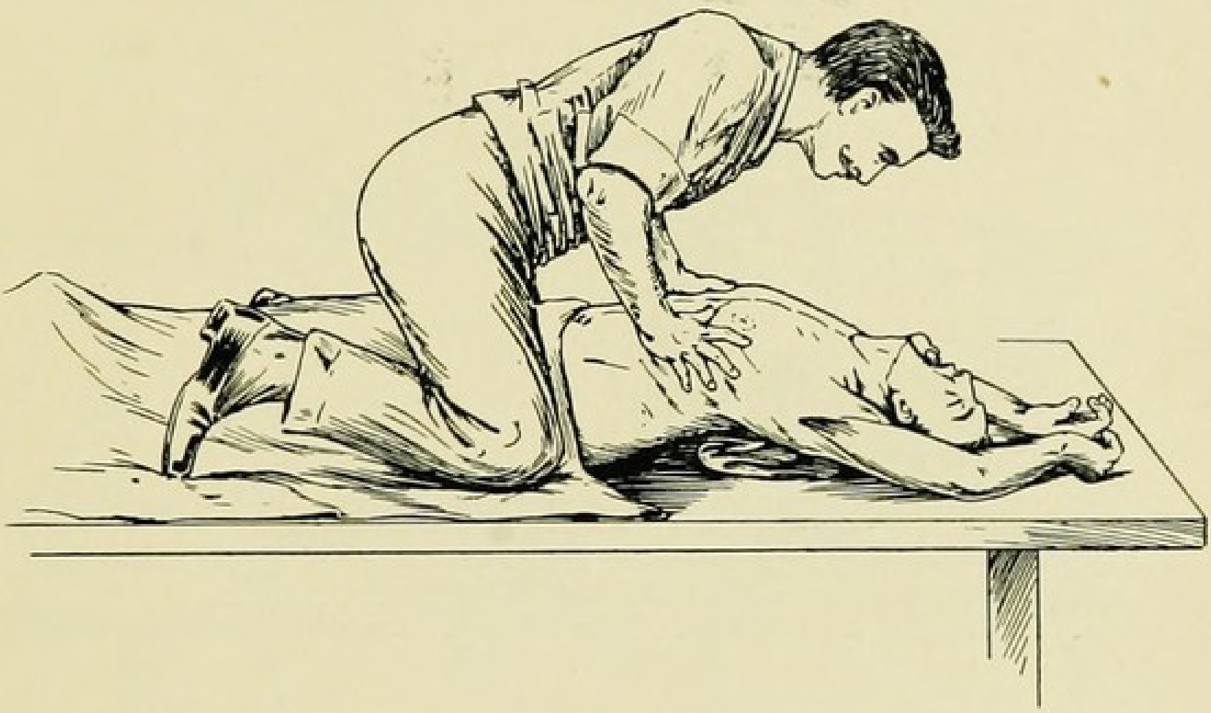

Fig. 35.—Artificial Respiration by Howard's Method—Expiration.

detail, there are one or two points that require attention. Firstly, artificial respiration is useless unless air can be made to enter and leave the chest ; hence one person must undertake the duty of maintaining a free air-way by means of a gag and tongue-forceps, a good position of the head, and sponging out the throat if necessary. Secondly, we must remember that the upper air-passages contain air which is charged with the anæsthetic vapour; and it is therefore important that the first act should be one which will drive out this air instead of sucking it into the lungs: hence, a forced expiration by compression of the chest should always precede expansion of the chest cavity. Thirdly, the frequency of the compressions should be not more than about twelve or fifteen per minute. The anæs-

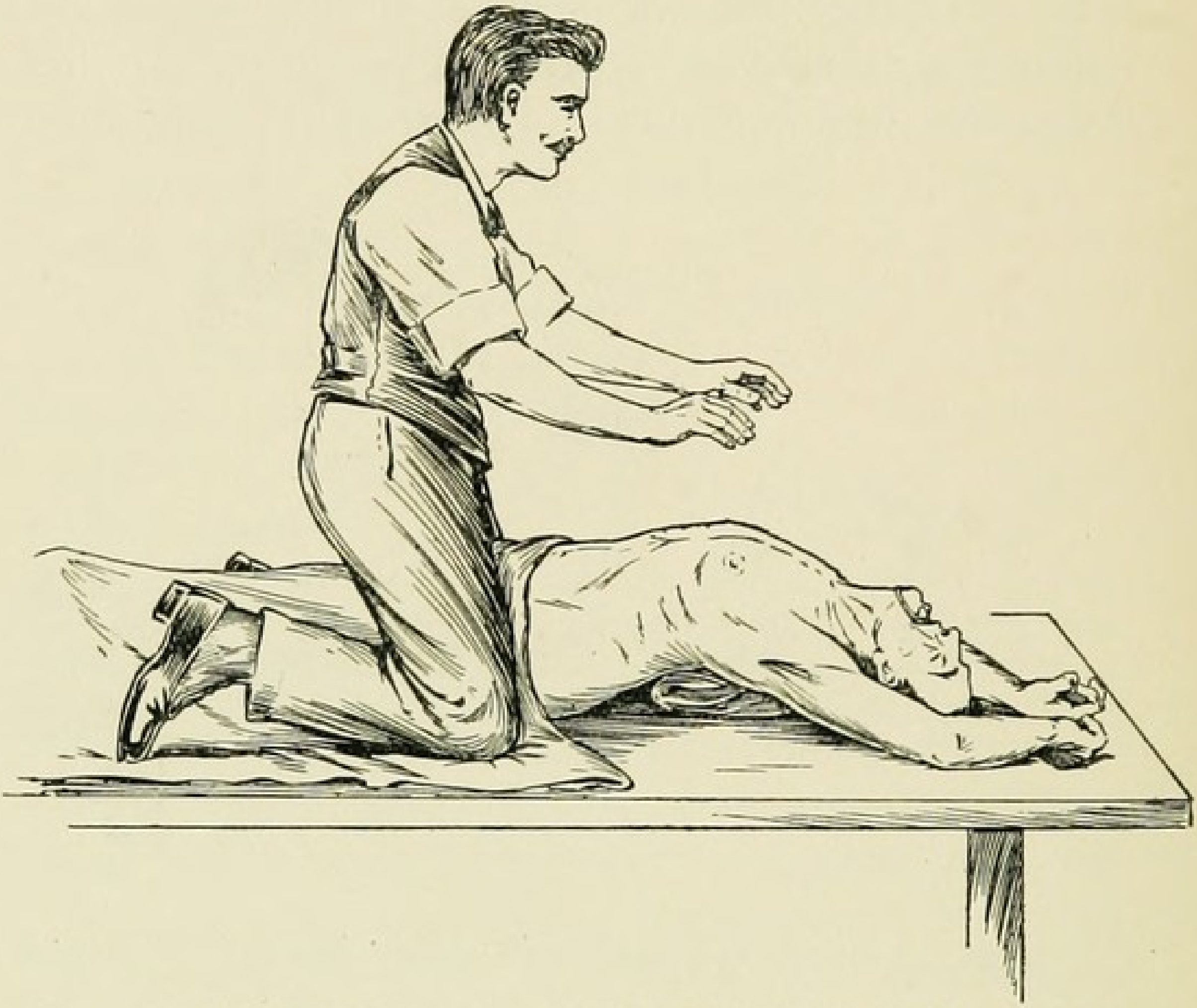

FIG. 37.—Artificial Respiration by Howard's Method—Inspiration.

thetist must not only keep calm himself, but he must also prevent anyone else becoming excited during the emergency, and trying to compress the chest at such a rate that no efficient entry of air can take place. For this reason, above all others, it is advisable never to allow a relative of the patient to be in the operating room.

The simplest method of performing artificial respiration is that of *Howard*, and consequently this is the one usually resorted to first. The shoulders of the patient should be somewhat raised by a sand-bag, and the head thrown back and kept in the mid-line, his arms being placed above his head. The operator then kneels astride

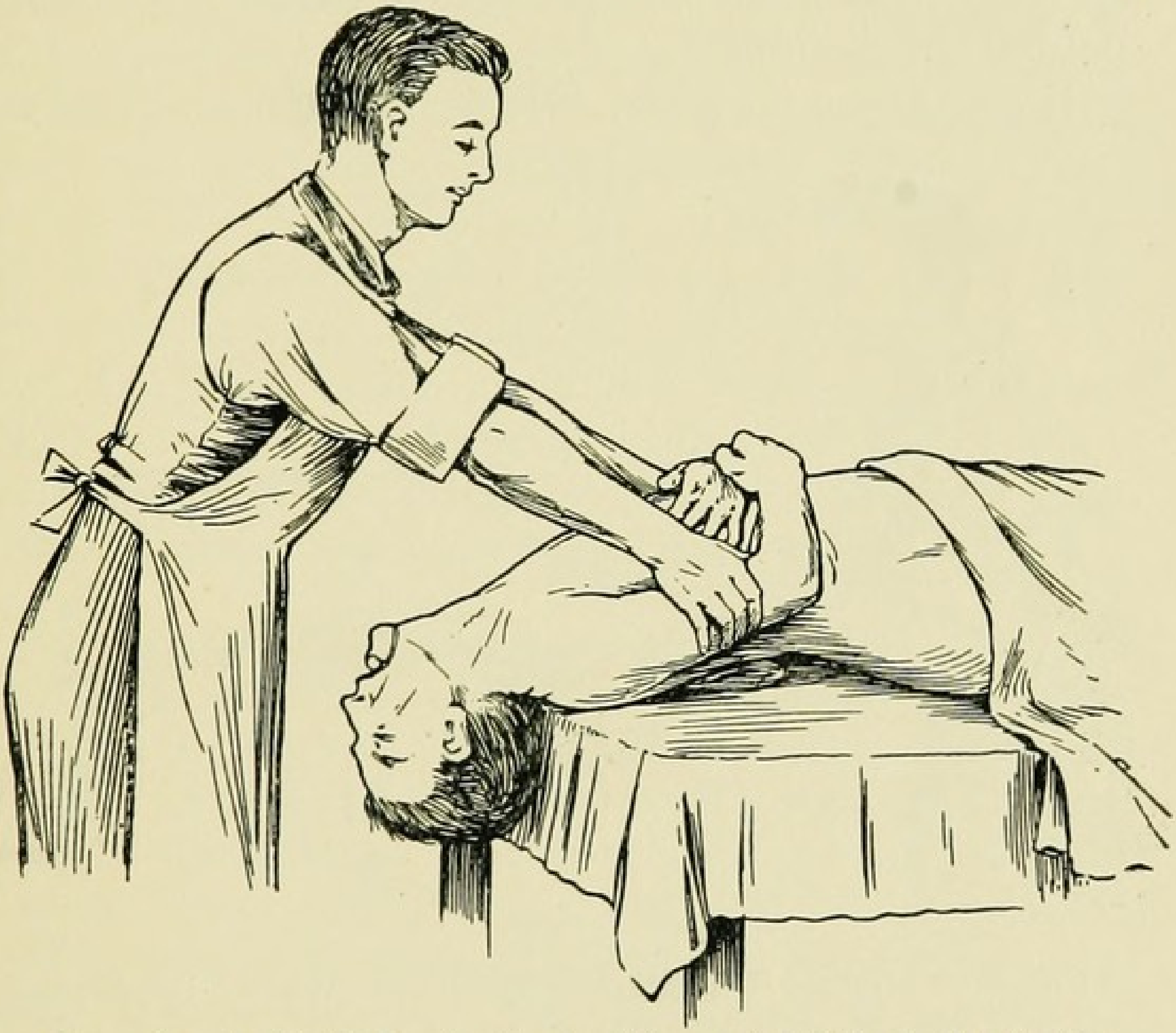

FIG. 38.—Artificial Respiration by Sylvester's Method—Expiration.

the patient's hips, and spreads out his hands over the lower part of the chest wall, with his two thumbs almost meeting over the xiphoid cartilage. He then throws his weight forwards, as shown in fig. 36, and compresses the patient's chest in an upward and inward direction. This compression should be maintained for a second or two, and then suddenly released by the operator jerking himself upwards into the erect kneeling position, as shown in fig. 37. After a rest of two or three seconds, these motions are repeated; great care being taken to make the compression at the same moment as any natural gasp, and to relieve the pressure instantly if the patient should make any effort at natural inspiration.

If air cannot be made to enter the chest sufficiently

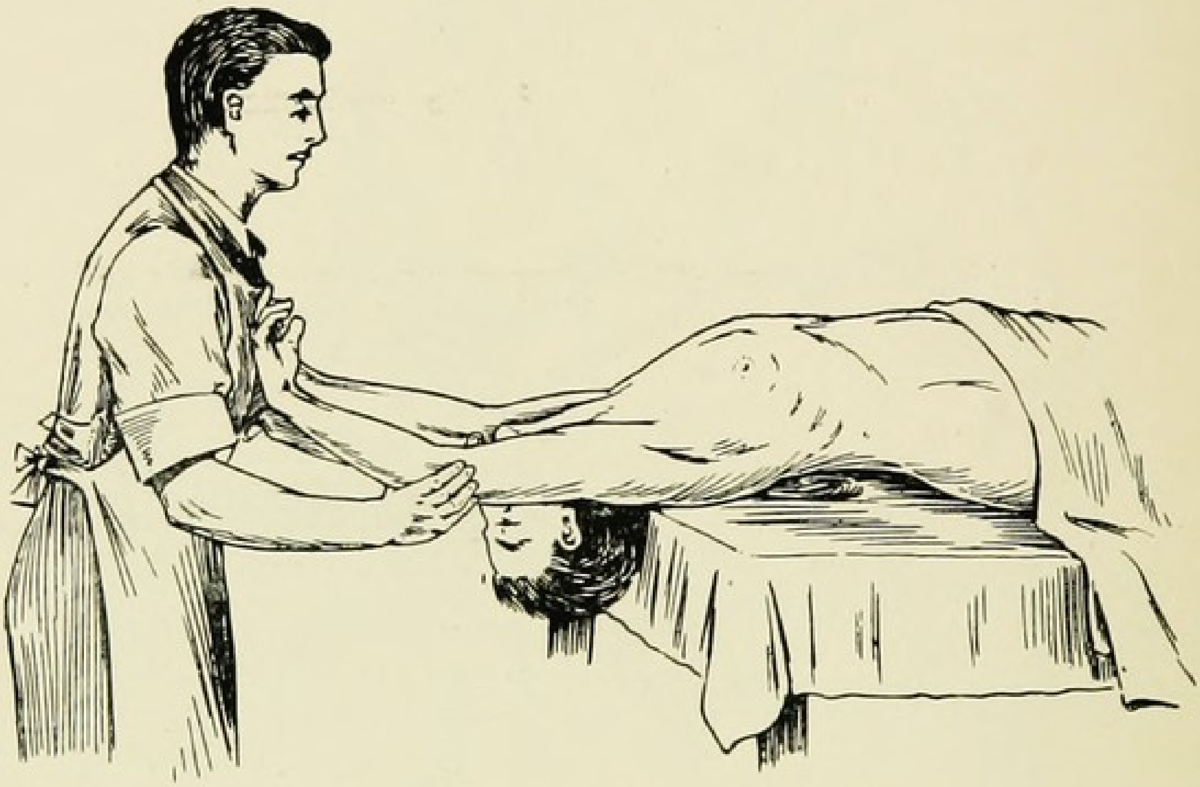

FIG. 39.—Artificial Respiration by Sylvester's Method—Inspiration.

by this method, it must be replaced by *Sylvester's*. In this case, the operator stands at the head of the table and grasps the patient's arms just above the elbows. He then forces the latter against the lower part of the chest (fig. 38) in order to drive out as much air as possible. At the same time, an assistant may with advantage press with his hands upon the abdomen, so as to make the expiration more complete, and also to assist in emptying the large abdominal veins of their blood. The pressure is then released, and the chest expanded by pulling the patient's arms right up above his head, as shown in fig. 39. This position should be maintained as long as any air can be heard entering. Then the pressure is again made, and so on until natural respiration is restored, or until all hope of saving the patient's life is entirely lost. In some cases, life has been saved after two hours' continuous artificial respiration, so hope should not be abandoned too readily. The good effects of these restorative measures will be greatly enhanced by an assistant directing a stream of oxygen towards the patient's mouth. If there be other assistants in the room, one of them might prepare and administer a hypodermic injection of strychnine, ether, or brandy; but the artificial respiration must not be stopped for a moment.

2.—Circulatory Troubles.

Primary failure of the pulse may occur reflexly, as a result of the surgical procedure, during a light anæsthesia. It also occurs occasionally from an overdose of chloroform; and finally, during the anæsthetization of extremely exhausted subjects, the pulse may stop before the respiration. The treatment would be to stop the anæsthetic and to immediately lower the head, and if possible invert the whole patient. Sometimes the heart can be stimulated by making a few rapid compressions with the hand passed up under the ribs, especially in children; and Mr. Arbuthnot Lane[1] has recorded a case of restoration by making an incision

[1] *Lancet*, November 22, 1902, p. 1397.

in the epigastrium, and compressing the heart directly with his hand through the diaphragm. A similar case was recorded in the *Lancet* of November 17, 1906, p. 1380. Mr. James Cantlie has tried cutting down upon the heart directly through the ribs ; but this operation occupies more time, and thereby diminishes the chances of success. One naturally hesitates to suggest that these heroic methods of resuscitation should be the routine treatment for cardiac failure during anæsthesia, but when this condition occurs *during an abdominal operation*, the direct compression of the heart through the wound should certainly always be practised instantly. Hypodermic injections of stimulants are useless in these cases ; as there is no circulation to carry the drugs to the important centres in the brain.

If the failure be more gradual, a rectal injection of saline solution containing brandy should be given ; or the solution may be infused into the loose areolar tissue of the axilla, or directly into a vein. Hypodermic injections of adrenalin, strychnine, ether, or brandy should also be administered. Hot bottles and flannels should be placed about the patient, and the temperature of the room raised. As soon as any marked circulatory depression is noticed during an administration of chloroform, this drug should be changed to the C.E. mixture ; and if the mixture were already being employed, plain ether should be substituted. In other words, whatever anæsthetic was causing the heart failure, it should be replaced by a more stimulating drug.

The majority of deaths that occur during the administration of chloroform occur before the patient is fully under, and most of these are due to a sudden overdose at the end of the struggling stage. Hence, if possible, ether should be administered during this period; but if chloroform be essential, the mask should be removed from the patient's face during the deep breathing which immediately follows the struggling. Some of these early deaths are probably due to fear, and in cases where the patient is obviously very frightened, chloroform had better be avoided, at least for the first ten minutes.

In very desperate cases, acupuncture of the ventricles of the heart may be performed, or even an injection of a stimulant administered into the heart substance. Some place great faith in electricity, but it seems almost as likely to inhibit as to stimulate the heart's action. The inhalation of nitrite of amyl is said to have revived some cases; but in using this, if the breathing has ceased, artificial respiration must be employed, otherwise none of the drug will enter the system. Syncope sometimes occurs from the heart being unable to cope with the sudden rise of blood-pressure that occurs after an inhalation of chloroform vapour has been stopped, either during or immediately after an operation. It is in these cases that nitrite of amyl is of special service, as it almost instantly causes a lowering of pressure, and the heart is then once more able to carry on its work.

Dilating the anus has a marked reflex stimulating effect on the respiration during light or moderately deep anæsthesia, but it could hardly be expected to act when the narcosis has become so deep as to paralyse the respiratory centre. Yet I have seen it tried (without any effect) on one or two occasions.

Presenting the vapour of ammonia to the nostrils during natural or artificial respiration has frequently been used on account of its stimulating action; and there is one case on record in which a handkerchief saturated with a strong solution of ammonia was held over the patient's nose and mouth for twenty minutes during artificial respiration, the breathing having ceased during an administration of nitrous oxide gas. The patient of course died from acute inflammation of the bronchi, trachea and lungs, due to the irritation caused by the ammonia. If used at all, it must be weak, and not held too near to the nostrils; nor must it be continued for more than a minute or so.

Nitrous Oxide Gas is a comparatively safe anæsthetic, except in cases in which there is pre-existing narrowing of the upper air-passages; and in these it should be avoided; for the cutting off of the air-supply will cause congestion, which will increase the obstruction already existing, and may kill the patient. The other difficulties and dangers connected with this drug are due to muscular spasm, which is asphyxial in origin. There are a few exceptions, such as the entrance of a tooth into the larynx, or keeping the inhaler on the face until the patient is suffocated; and Dr. Hewitt quotes a case of death from apoplexy, of a man, aged 49, five hours after an administration of nitrous oxide gas.

Spasm of the masseter muscles should be guarded against by placing a dental prop between the teeth before commencing the administration.

Should respiration cease, the anæsthetist should always pass his finger to the back of the throat to make sure that there is no foreign body within reach; and at the same time he can hook the base of the tongue forwards with this finger, which will often by itself be sufficient to cause the breathing to recommence. Otherwise, artificial respiration must be at once performed, the patient being placed upon the floor for the purpose.

Occasionally, vomiting occurs during an administration, and asphyxia may result from the inhalation of some of the vomited matter, especially if the head be thrown back, and a careful watch be not kept on the patient. Alcoholic subjects and heavy smokers are liable to become rigid during the administration, and sometimes struggle to such an extent as to interfere considerably with the operation.

Ethyl Chloride, like nitrous oxide gas, should be avoided in the case of those whose respiration is in any way embarrassed. It is also not suitable for strong or alcoholic men, except as a preliminary to etherization. It is most important that the drug should be absolutely pure, otherwise difficulties are liable to arise. These are nearly always respiratory, but a few of the recorded fatalities are said to have been brought about by cardiac failure. Vomiting seldom, if ever, occurs during induction; but it is somewhat frequent during recovery. Movements and rigidity are less common with ethyl chloride than with nitrous oxide, and jactitations ought never to occur. Nose-bleeding occasionally occurs, but it is not serious. Profuse sweating also sometimes takes place, and may lead to the patient catching cold, unless care be taken.

The difficulties and dangers of **Ether** anæsthesia are almost entirely confined to the respiratory system, and have mostly been considered in the chapter dealing with the administration of ether. Deaths are usually due to either an overdose of the drug, or an insufficient supply of air. In the case of an overdose being given, the breathing always ceases some considerable time before the heart is dangerously affected; and therefore the majority of patients revive if artificial respiration be practised efficiently and without delay.

Muscular spasm may interfere with free respiration in many ways: spasm of the masseters will prevent the free entry of air through the mouth; and spasmodic drawing back of the tongue, or laryngeal spasm, will occlude the larynx. Occasionally, spasm of the chest muscles entirely stops the breathing, but fortunately such a condition is rare. Muscular tremors are sometimes seen during light narcosis, but pass off when the administration is pressed. During abdominal operations, muscular rigidity or excessive respiratory movements may greatly interfere with the surgeon's manipulations. As a rule this will subside with a deeper anæsthesia if the air-way be free, and a more liberal supply of both air and ether be given: if, however, it persists, a change to chloroform may become necessary. Snow pointed out long ago that more perfect muscular relaxation can be obtained with ether than with chloroform, and this is quite true, but it cannot always be obtained immediately. In certain cases a profound narcosis must be maintained for several minutes before all rigidity is entirely subdued. One cannot always know beforehand whether muscular rigidity will cause trouble, but it is more likely to occur in neurotic people. It is also frequently seen in those who have suffered from severe localized pain: in these cases, rigidity of the muscles over the painful area may persist for a considerable time after deep anæsthesia has been produced.

One of the great drawbacks to ether is the excessive secretion of saliva and mucus which it sometimes causes. This is usually due either to a too limited supply of air, or to the anæsthesia not being kept at an even depth throughout the administration. When it occurs, more air should be admitted, and if the secretion continue to increase in spite of this, chloroform should be substituted for the ether without delay; otherwise a tranquil anæsthesia will be impossible, and suffocation of the patient may even occur. A few cases of cerebral hæmorrhage have occurred under ether, and this drug should therefore be avoided in any case with marked atheroma, or with a history of a previous attack of hæmorrhage.

Under **Chloroform**, the majority of deaths occur during the first ten or fifteen minutes of the administration, and are caused by its action upon the heart. The most frequent sequence of events is:—firstly, too strong a vapour is presented to the patient, which causes struggling to occur. During this struggling the patient holds his breath and partly asphyxiates himself, one result of which is to dilate the right side of his heart. He then becomes exhausted and ceases to struggle, at the same time taking a deep inspiration. A large amount of chloroform is thus absorbed by the blood in the pulmonary capillaries, and carried to the right heart, which is already fatigued by the struggling and dilated as a result of the asphyxia. The heart therefore becomes paralysed by the direct action of chloroform upon it.

Another factor which contributes to these early deaths is *fear*. A patient who is pale with fear comes to the operation with his circulation already considerably depressed, and the additional depressing effect of chloroform may cause sudden death.

Cases are also recorded of deaths having occurred suddenly when the first incision has been made during a light anæsthesia; but opinions differ on this point. The mechanism causing death in this class of cases has been explained in the following theoretical manner: The heart is accelerated by the vaso-motor nerves, and inhibited by the vagi. When no anæsthetic is employed during a small operation, the accelerator and the inhibitory actions are both stimulated to a corresponding degree, and a normal heart is not notably affected. During incomplete narcosis, however, the vaso-motor centre is paralysed before that of the vagus; and consequently a shock at this period may produce undue inhibition of the heart's action. This effect is impossible during complete anæsthesia, owing to the reflex vagus sensibility being also abolished.

If the induction stage be hurried too much, spasm of the larnyx and struggling may occur and lead to a fatal result, as stated above; but if, on the other hand, the induction be unduly protracted, syncope may also occur, owing to impending vomiting. When death takes place later in the administration it is nearly always due to the paralysing effect of an overdose of the chloroform. But even these late cases are sometimes the result to a large extent of the direct action of chloroform on the heart, especially when the latter is dilated as the result of any intercurrent asphyxia.

It is, therefore, most important, when administering chloroform, to avoid any cyanosis of the patient at all; whereas with ether, as we have seen, a certain amount of cyanosis, though better avoided, is of little practical importance.

Sudden death during the administration of chloroform is particularly liable to occur in children who are in a "lymphatic state"; nor is this surprising, as these subjects sometimes die suddenly from cardiac syncope quite apart from any anæsthetic. Such patients should be anæsthetized by means of ether or the C.E. mixture, which would tend to stimulate the heart's action instead of further depressing it, as is the case with chloroform. A deep anæsthesia should be maintained in order to obviate as far as possible any reflex shock. The most notable features of these cases are persistence or hyperplasia of the thymus gland, together with hypertrophy of the spleen, tonsils, adenoids, follicles at the base of the tongue, Peyer's patches and solitary follicles, and sometimes an enlarged thyroid gland.

The difficulties that may occur during certain special operations, or in patients suffering from certain pathological conditions, have been considered in Chapter V.

A difficulty one sometimes meets with in private practice is to make up one's mind which risk to take when one has to anæsthetize a patient on a cold night in a small room lit by gas, lamps, and candles. If we employ ether, we may have an explosion; whereas if chloroform be chosen the vapour will be decomposed by the naked flames into phosgene gas and hydrochloric acid, which will cause great irritation to the eyes and throat of everybody in the room; and has proved fatal sometimes to the patient, and on one occasion at least to the operator also,[1] and once to a nurse. I suggested a cold night as one of the factors in the difficulty, because one would then hesitate about opening a window.

THE ANÆSTHETIST'S ARMAMENTARIUM.

Before commencing to administer an anæsthetic, the anæsthetist should always have close at hand an alternative anæsthetic, and the apparatus required for its use; a gag (Fergusson's or Mason's); mouth-props; a wedge-shaped mouth-opener; tongue-forceps; a hypodermic syringe, and a supply of strychnine, ether, and brandy; a set of tracheotomy instruments; a few throat sponges; a towel; a porringer; and in special cases he should be prepared with a bottle of oxygen gas, some capsules of nitrite of amyl, and some ammonia solution.

[1] *Lancet*, June 24, 1899.

CHAPTER XII.

AFTER-EFFECTS AND THEIR TREATMENT.

THE after-effects and the length of time occupied in recovery from an anæsthetic depend mainly upon the drug used and the duration of the narcosis.

If *nitrous oxide gas* has been administered, there is no special discomfort afterwards. Vomiting is rare, unless food has been taken shortly before the administration, or blood has been swallowed. It is more frequent in the case of boys between the ages of 12 and 15 than in other subjects. When adults suffer in this way, they are usually people who are naturally prone to sickness. Headache is more common, and sometimes lasts for a whole day. An attack of syncope is occasionally met with, especially in children, but it seldom requires any treatment beyond letting the patient lie down for a quarter of an hour or so. It is important that the patient be allowed to "come round" gradually: if recovery be hastened by slapping or shaking, the after-effects (especially headache) are always more marked. A gentle current of fresh air is beneficial.

After taking *ethyl chloride*, the patient feels drowsy for a time, but this soon passes off when he breathes the fresh air. Headache and giddiness are sometimes met with. Neurotic patients may weep, laugh, or throw themselves about in the chair or on the couch, and powerful men and alcoholics sometimes struggle and fight vigorously. Vomiting occurs about once in ten or twelve cases, but this average includes hospital out-patients, who frequently take food shortly before the administration, in spite of warning. As a rule the sickness passes off in a few minutes, and I have never known it to require any treatment. Hysterical subjects are more liable to vomiting than other people. Retching and a feeling of nausea are not uncommon. A slight degree of faintness occasionally occurs, but it seems to be connected with the vomiting. Immediately a dental operation is completed, the patient should be bent forwards in the chair, so as to allow any blood to escape freely from the mouth, instead of being swallowed or inhaled. If the operation has been performed while the patient was lying down, he should be turned over on to his side, or even into the prone position, for the same reason. It is advisable to let every patient lie quiet for at least ten minutes after recovery from ethyl chloride.

With a few exceptions, the after-effects due to *ether* and *chloroform* are sufficiently alike to be considered together. The most frequent is vomiting, but there may only be retching or a feeling of nausea. These are more frequent after ether than after chloroform; but the chloroform sickness, when it does occur, is more severe and lasts longer than that due to ether. The careful preparation of the patient has a great influence on the after-sickness, and it is more likely to occur in certain subjects than in others: thus, the aged, and also young infants are seldom sick at all, whereas older children and adults suffering from tuberculous glands in the neck, or tubercular hip-disease hardly ever escape. The uniformity of the depth of anæsthesia maintained, and the care taken to prevent the swallowing of mucus, saliva, blood or pus, play an important part in this respect. As soon as the operation is completed, the patient should be removed to bed with the least possible amount of shaking. He should then be turned completely on his side, with the legs bent up and a pillow along the back to prevent rolling over. This position is the best, as it avoids the risk of any vomited matter being inhaled. The head should be supported on a low pillow in a straight line with the body. If the patient complain of thirst, he may be given either very hot water to sip, or some tea containing only a little milk and no sugar. No other food should be allowed for at least four hours; at the end of which time a small quantity of meat essence or strong beef-tea may be given; and if that does not cause sickness, it may be repeated in a larger quantity after about two hours. For the rest of the day the patient will not require more than some tea and dry toast, or some clear soup. Milk, bread and milk, or milk puddings will almost certainly cause vomiting, and had better be avoided. If there be great shock, or if much blood has been lost, and it be desired to give nourishment or stimulants as soon as possible after the operation, a beef-tea enema containing brandy may be administered when the patient is back in bed. Sometimes patients are sick after taking tea or meat essence, and then a little iced beef-tea or iced soda-water may be tried. Hot black coffee, with 10 grains of bicarbonate of soda in it, is advocated by some, as also is iced dry champagne. Sucking a piece of lemon is a well-known and sometimes efficacious remedy for post-anæsthetic sickness, just as it is for sea-sickness. Should the vomiting persist for more than twenty-four hours, there is no reason why morphia should not be administered; and should this fail, the stomach should be washed out with warm water containing carbonate of soda. For cases of severe vomiting after the inhalation of ether, Professor Hare recommends a 2-oz. or 3-oz. starch enema containing 30 minims of tinctura opii deodorata, and 30 grains of bromide of soda. Dr. Paterson,[1] of Glasgow, recommends picrotoxin as a preventive of post-chloroform sickness. He uses a 0·2 per cent. solution in sterilized water, and injects 20 minims of this solution hypodermically for adults, and less in proportion for children, immediately after the operation and before the patient is removed from the table.

After the patient has been placed in bed, he must not be left unattended until he has completely recovered consciousness. His head, and if possible his whole body, must be kept turned to one side to allow free escape of any vomited matter; and he must not be allowed to raise himself into the sitting position for at least two hours after inhaling chloroform, for fear of sudden cardiac syncope. He must be well covered up with warm blankets, and a screen should be placed round the head of the bed to protect him from draughts. Hot bottles should be placed about the body, and care must be take to see that they are thickly covered with flannel, so as to avoid the possibility of burning the

[1] *Lancet*, September 14, 1907, p. 794.

patient while he is still insensible to pain. Sometimes, shortly after the patient has been replaced in bed, he will be noticed to become pale and almost pulseless, while the pupils dilate, and the breathing becomes irregular, or even temporarily ceases. These symptoms frequently cause alarm to onlookers, but they only indicate the near approach of vomiting, and will right themselves as soon as this event has taken place.

Various paralyses are sometimes met with after recovery from an anæsthetic: the commonest of these is musculo-spiral paralysis, caused by pressure upon the nerve during the operation, and care should always be taken not to allow the arm to hang over the side of the table. Hemiplegia is uncommon, but has occasionally resulted from the administration of ether to patients suffering from marked arterial degeneration.

Unless care has been taken during an administration of chloroform, the face (and sometimes the neck also) may be burnt more or less severely by liquid chloroform running on to the skin, or from a wet mask being allowed to rest upon the face. The mode of preventing such an occurrence is obvious; but if the face does get burnt, it should be smeared over with vaseline immediately after the administration.

Delirium sometimes occurs for a day or two after an operation, and I have seen one case of a child, aged 4, who had an acute maniacal seizure for four days after chloroform anæsthesia. If a patient has any tendency to insanity, the mental derangement caused by an anæsthetic, especially chloroform, may lead to a fresh outbreak. A few cases have been reported of patients remaining in a condition of profound stupor, if not of absolute unconsciousness, for two or three days after anæsthesia.

Renal complications may be set up by either chloroform or ether, but are more frequent after the latter drug. A certain amount of transient albuminuria is quite common, and of no importance. As stated in Chapter III., deaths have occurred from suppression of urine after ether administration. The treatment of suppression or deficient excretion of urine after etherization consists of :—

(1) Circulatory stimulants, of which the best are strychnine and digitalis ;

(2) Copious injections of normal saline solution into the lower bowel ; and

(3) A vaso-dilator, of which the best is nitro-glycerine which may be administered either by the mouth or hypodermically. I have recently heard of one case of a child, aged 3, who died on the second day after chloroform anæsthesia with signs of uræmia. The operation was for the removal of tuberculous glands from the neck, and nothing unusual occurred for the first twenty-four hours after the operation, but from this time onwards no urine was secreted at all.

Bronchial and pulmonary complications may follow anæsthesia by ether or chloroform, but are more common after ether. These are doubtless caused partly by the anæsthetic itself, but the majority of cases are due to other factors. Respiratory complications are most common after abdominal operations, in which a large surface of the body is exposed, and usually for a long time. The theatre during an abdominal operation should, therefore, be warmer than is necessary during other operations. Another likely cause for the greater frequency of respiratory complications after these operations is that the surgeon often requires his patient to lie flat on his back during recovery. In such a position, small quantities of vomited material may easily be inhaled, especially before the patient is fully conscious. The interference with free breathing due to tight bandaging may well be regarded as a further cause of pulmonary complications. Finally, aged people may develop hypostatic pneumonia if kept lying flat in bed for many days, without any anæsthetic being used at all; but if the patient has been anæsthetized, the anæsthetic is certain to receive all the blame. However, in a great many cases, the anæsthetist can undoubtedly do a great deal to prevent the occurrence of bronchial or pulmonary affections, by a careful choice of the drug and the particular method of administration that he employs in any given case; and by attending to the temperature and ventilation of the room, and the covering of the patient both during and after the operation. He should not allow all the doors and windows in the room to be thrown open, so as to get rid of the unpleasant smell of ether for the benefit of the rest of the household, at the expense of the patient; and he should not leave his patient at the end of the operation until he has seen him safely back to bed, well covered up, in a good position, with at least his coughing-reflex restored, and free from any risk of inhaling vomited matter.

If there be any special reason for fearing that pneumonia may supervene, as, for instance, when the patient is very old, it is a good plan to place him in bed upon one side after the operation; and at the end of an hour to have him turned on to the other side, and then back again on the expiration of another hour, and so on.

Fatty degeneration of the viscera, especially of the liver and kidneys, occasionally follows an administration of chloroform to unhealthy and rickety children, particularly girls; and is always found *post mortem* in cases that have died from so-called "*delayed chloroform poisoning.*" It is always associated with severe vomiting, and most frequently occurs in patients who are subject to periodic attacks of sickness. The symptoms usually commence about twelve or twenty-four hours after the operation with restlessness, air-hunger and vomiting. Acetonuria is also found in these cases, but the real cause is not fully understood, and is undergoing investigation at the present time.

General Surgical Technique.

BY

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GENERAL SURGICAL TECHNIQUE.

CHAPTER I.

PERSONAL PREPARATION OF THE SURGEON AND ASSISTANTS.

WHAT is the most desirable asset for a modern surgeon? A well-developed aseptic conscience! This applies not only to the regulation of his work and environment in the operating theatre and wards, but also to that of his daily life. The attainment of successful results demands constant watchfulness against contamination from the manifold sources through which such may occur.

In active surgical life, regular habits are not possible, therefore to maintain an essential *mens sana in corpore sano* extra care is required.

To a busy man the advice that his first duty is to himself is a counsel of perfection. Nevertheless, his aim should be to keep himself in the best health possible. Unsuitable foods, irregular habits, want of sufficient sleep and exercise, and over-indulgence in luxuries, interfere with the proper discharge of the functions of the alimentary canal—the *prima via*. The results of such interference predispose to vicious circles of indigestion and bad temper, which influence both manual and mental work. The condition of things elsewhere is indicated by the presence of foul breath and deterioration of teeth. The bowels must be most carefully regulated. The mouth and teeth must be cleansed several times daily with some antiseptic powder or wash. The teeth should be scaled by a dentist every few months, especially if smoking is indulged in. During the daily bath, the armpits, upper arms and head should have most thorough attention. Above all things, scrupulous and continuous care must be bestowed upon the hands, which are chiefly concerned with conveyance of infection, in that they come into most direct contact with the wound. Other paths of infection may be shut off by the use of aseptic overalls, masks, caps, and so on. Gloves may be used. They are but a thin line of defence, too easily pierced. The routine use of gloves demands practically the same careful treatment of the hands, otherwise sooner or later calamity will occur.

The surgical aseptic conscience is an acquired virtue! One must not parade it, otherwise it becomes almost a vice! A thorough understanding of the principles of bacteriology is essential to its full development. A proper appreciation of his responsibility in this warfare against contamination is not possible to a surgeon who is ignorant of the why and wherefore of bacteriology, and the all-important *rôle* which bacteria play in the inflammation of infection.

PREPARATION OF THE SURGEON'S HANDS.

While the disinfection of the hands immediately previous to operation is, of course, the most important question which has to be considered in this connection, yet the care of the hands at all times is a matter of only slightly less importance and one to which, usually, too little thought is given. A surgeon who wishes to have consistently good results from his operative procedures must maintain a constant watchfulness against contamination of his hands, not only during enforced attention to glaringly infective cases, but also during the ordinary performance of his daily work and pleasures. He should develop an almost morbid aversion to handle directly anything which may seriously soil his hands in a surgical sense. He should endeavour to keep his hands smooth and well-cared for, so that, should contamination occur, disinfection will be easier. Therefore he should wear gloves, constantly in winter, when out of doors, and, unless on prolonged holiday, especially during indulgence in field sports, pastimes, or gardening, as his hands may otherwise become infected by organisms or spores which are particularly difficult to get rid of. Gloves, made of material which will stand washing every few days, should be used. I have found strong, loosely fitting buckskin gloves the best for ordinary wear. Really good ones, when well taken care of, last for a year or more. Several pairs should be kept. If, inadvertently, the hands become soiled, the septic material should be thoroughly removed as soon as possible, so that it does not become worked into the epidermis. If during the day the hands have been seriously soiled by pus, earth, or other infective material, just before going to bed they should be soaked and scrubbed in hot soap and water, dried, and then glycerine vigorously rubbed into the skin, especially under and around the nails and between the fingers. The glycerine should not be wiped off. It will do no harm to the bedclothes and in the morning it will be found that the skin, especially of the folds around the nail, is soft and easily cleansed.

There is no doubt that under ordinary conditions the hands tend spontaneously to free themselves of virulent organisms, and will do so in a very few days, but even artificial disinfection is not to be relied on to get rid immediately of organisms which, one would think, have not had time to penetrate the deeper layers of the skin. The minute care required during the cleansing process may be indicated by the difficulty of removing plaster of Paris which has been allowed to dry on hands from which the natural grease has been removed previously by the process of disinfection. The particles of plaster, which are infinitely larger and easier of removal than micro-organisms, have a knack of showing in the crevices of the skin after the hands are dry. (In passing, it may be said that the writer finds the best method of preventing plaster making its way into these crevices is by carefully smearing the hands, especially around the nails, with sterilized vaseline. This prevents the plaster setting on and adhering strongly to the cuticle. The vaseline is easily dissolved and the plaster particles removed by the use of turpentine and a nail-brush.)

There are many methods used for disinfecting the hands preparatory to operating, and the various methods have each strong and able advocates. Salvation lies in the fact that probably more depends on the thoroughness of the performance of any method rather than on any inherent virtue which it is supposed to possess. *Removal of the infective material* by mechanical or chemical (fat-solvent) means must be the basis on which hand disinfection rests. Attempts at destruction of micro-organisms *in situ* by antiseptics alone cannot be relied on, as these either coagulate albumen and thus defeat their object by forming a protective barrier round the organisms, or else they do not dissolve fat and therefore do not get at the organisms on the surface, much less penetrate into the skin. Yet how often does one see whole-hearted reliance on watery solutions of antiseptics, to the extent often of the belief that mere wetting of the hands for a second or two is sufficient! Prior to, or along with the use of the antiseptic, some fat-solvent is essential. Soap and water, turpentine, alcohol, ether, methylated spirit, are some of the more commonly used. Soap (preferably soft soap) is better to be mixed with fine sand, powdered pumice, or marble—the scouring effect of the latter easily removes superficial effete epithelium and other "dirt." Deeper septic material (in the furrows and follicles of the skin) is removed by the to and fro scrub of a fairly hard brush, whose bristles ride over and dip into the unequal ridges and furrows of the skin. In the preliminary stages, liquid soaps mixed with ether or turpentine to strengthen the fat-solvent action are often used. After the removal of the gross "dirt" in this way, concentrated, more penetrating solvents, such as spirit, alcohol, ether, or turpentine, are employed, and the scrubbing brush is essential here also. The antiseptic may be used in combination with the spirit or alcohol, but some prefer a watery solution which is enabled to reach the epidermis and fasten on to any remaining bacteria there, now that the fats naturally present are removed. One must choose a process which damages the skin and nails least, so that these are preserved as smooth as possible. It is extraordinary how one person can use, with impunity, strong solutions of an antiseptic (*e.g.*, carbolic or sublimate), while even the weakest solutions so act upon the skin of another person that it becomes rough, cracked, or affected with dermatitis. Such a skin is extremely unpleasant to the owner; it collects dirt easily, and is much more difficult to disinfect. One must find out the method which suits the skin best and carry it out with the utmost thoroughness, and the results will be equally satisfactory. Make the mechanical removal of infective material the main object—further procedures are of secondary importtance, but necessary all the same. Much practice is required before the hands can be satisfactorily cleaned. The process entails great care and plenty of time. One must remember that each little area of the hand or forearm that comes in contact with the wound or its surroundings may be capable of bearing infection; also that bacteriologists assert that it is impossible to make the hands sterile! We should make them as sterile as we can, and we can bring about such a state of things that the knocked-about, poison-soaked microbe has no chance in the warfare against the forces brought against it in a properly cleaned and closed wound, unless it sneak in under shelter of a ligature or suture, which, of course, it is very likely to do. It can easily be nursed back to activity from its bruised and bedraggled condition, by the warmth, good feeding, and hygienic surroundings of the experimental test-tube or Petri dish! Almost as favourable conditions exist in blood-clot or serum effused in a wound! To arrive at approximate perfection requires that plenty of time, scrupulous care, and common-sense be used on each occasion by one whose hands have been in the intervals carefully tended, and who has had long practice in the process of hand disinfection. With ordinary soap and water and a nail-brush a mature operator can be guaranteed to render his hands purer than the embryo dresser can with the assistance of strong fat-solvents and antiseptics as well.

The writer's method is as follows: The nails are trimmed short and *smooth*. The shirt sleeves are turned up to above the elbow. The skin is softened at the beginning of the process by immersion for some minutes (the time, two to five minutes, varying with the condition of the epidermis) in as hot water as can comfortably be tolerated. If the hands are rough or have not been disinfected for a few days, Schleich's soap, or a mixture of sterilized soft soap and sand, is smeared over the hands and forearms as far as the elbows.

Formula of Schleich's Soap.

Soft soap	14 lb.
Ground white marble	22 lb.
Water	1 pint.
Lysol	24 fl. oz.

Heat soft soap with a little of the water; mix with other ingredients. Finally stir well.

For two to three minutes this is vigorously rubbed into all parts of the skin concerned. Every now and again the soap is moistened by the lapping up of a little hot water. Now with a sterile nail-brush (common fibre brush, $3\frac{1}{2}$ in. long, $1\frac{1}{2}$ in. broad, costing a few pence per dozen) every part of the skin is systematically and vigorously gone over till all the gritty particles are removed. This is done while the hands are immersed in the hot water. The water is then changed. This part of the process is sometimes repeated, fresh brushes being used if the hands have been much soiled. With another sterile brush turpentine soap is scrubbed all over and into the skin of the hands and arms until nearly dry.

Formula of Turpentine Soap.

Turpentine	1 part.
Glycerine	1 ,,
Soft soap	2 parts.

Heat soft soap and glycerine; strain through lint or muslin. Add turpentine when above is almost cool.

The brush is then dipped into water, and by scrubbing systematically each part as before an excellent lather is worked up. The soap is scrubbed off with another sterile brush, the hands and forearms being held under running water. Finally, the hands, especially, and forearms are scrubbed *in* a watery solution of biniodide of mercury (1 in 1,000). Special attention is given during the whole process to those parts which come in contact with instruments, swabs, ligatures, tissues (in grasping or otherwise manipulating these), or with the surface of the wound or patient's skin, or sterile sheets surrounding the wound. Such special parts are the palmar aspects of the thumbs, first and middle fingers, the lateral aspects of the two latter (for ligatures), the hypothenar eminence, the dorsi-ulnar aspect of the little and ring fingers, and the ulnar area of the forearm. It is rather interesting to note in visiting various operating theatres how frequently the backs of the fingers receive extra attention while the palmar surfaces are comparatively neglected.

It will be easily understood that this method of hand disinfection cannot be satisfactorily carried out under fifteen to twenty minutes. When the biniodide has been brushed off in sterile water, strong scraping of the skin with the edge of a blunt scalpel very rarely indeed produces material which will furnish any growth when transferred to a culture tube.

After disinfection is completed, in order to avoid contamination, the hands should be held up, elbows flexed to an acute angle. One soon does this instinctively. It acts as a danger signal to others, warning them from contact.

The skin of the writer's hands deteriorates rapidly when alcohol, ether, spirit, carbolic, or corrosive sublimate solutions are used. They keep perfectly smooth so long as the above routine can be followed. Before leaving the operating theatre, the hands are thoroughly washed with ordinary soap and water, so as to remove any mercurial salt; they are dried and then some weak antiseptic ointment with lanoline as its basis is thoroughly rubbed into the skin so as to replace the natural fats which have been removed; the excess is wiped off with a towel, to remove any greasy feeling. Some such precaution is frequently necessary in order to prevent the epidermis from becoming dry and cracked.

Before the fingers are introduced into the depth of a wound, *e.g.*, into the abdominal cavity, they are *scrubbed* in normal saline solution, in order to remove any germs of infection which might have been picked up from the patient's skin during incision thereof. During a prolonged operation they are frequently cleansed in this manner, so that the pores of the skin may be cleared of any organisms which are being squeezed out from the depths. J. B. Murphy, of Chicago, suggests that dried blood should not be washed off—it forms a film on the skin which prevents the escape of organisms which may have been forced out of the pores of the skin.

Cuts and punctures of the hands must be carefully treated in order to prevent them becoming septic and infective. The writer finds the following to be the best procedure :—

Thoroughly disinfect the wound and adjacent part. If the wound tends to gape, put on a small piece of antiseptic adhesive plaster, after approximating the edges, and then wind several layers of " heftband " (Hutchinson) round the part. If the wound is in the neighbourhood of a joint, sufficient heftband should be applied to act as a splint which will prevent movement. The heftband does not adhere to the skin and therefore does not cause any difficulty or discomfort in removal. These dressings maintain the asepticity of the wound and are removed at each operation.

The following are some of the methods of disinfection of the hands in most general use :—

(1) *Furbinger's Method.*—The nails being cut short and the subungual spaces thoroughly cleansed, the hands are scrubbed with a sterilized brush in soap and water, as hot as can be borne. They are then washed for a minute in alcohol not below 80 per cent., and afterwards rubbed in a 3 per cent. solution of corrosive sublimate.

(2) *Ahlfeld's Method.*—After cutting the nails and cleaning the subungual spaces the hands are washed for five minutes with hot water and soap, rinsed in clean water, and then brushed with pure alcohol. This is followed by a thorough rubbing with flannel soaked in alcohol.

(3) *A method in favour* in many hospitals *in Germany* is the following :—

The hands are soaked and scrubbed in the usual way with soap and hot water. They are then wiped thoroughly with sterile gauze soaked with a solution of ether, alcohol, and nitric acid.

Alcohol, 96 per cent.	1,000 parts.
Ether	500 „
Nitric acid	7·5 „

(4) *Potassium Permanganate and Oxalic Acid Method.* — The hands and arms are vigorously scrubbed for ten minutes with a sterile brush, using common brown kitchen soap, or green soap and hot water. The washing is to be kept up fifteen minutes by the clock, and during this time the water is changed four or five times. The hands are next steeped in a hot saturated solution of potassium permanganate until they are stained a deep mahogany colour. They are then immersed at once in a saturated solution of oxalic acid, which decolorizes and sterilizes them. The oxalic acid is then removed by rinsing in warm lime water, which precipitates oxalate of lime.

(5) *Nascent Chlorine Method.*—After scrubbing the hands and forearms with warm water and soap, one takes a few crystals of carbonate of soda (washing soda), and, dissolving these in a small quantity of warm water, rubs the solution well over the hands and arms. One next quickly applies about a tablespoonful of chloride of lime (bleaching powder) over the hands and arms, rubbing the resulting paste thoroughly over all. From this paste free chlorine is evolved. The rubbing is continued until the little rough grains of chloride of lime disappear or until the creamy fluid thickens into a pasty mass, when a sense of coolness is felt. This procedure occupies from three to five minutes. The paste is then washed off in warm sterile water and the hands are now ready for use. The odour of the chlorine may be removed by neutralization in a sterile 2 per cent. solution of liquor ammoniæ.

THE USE OF GLOVES.

Two kinds of gloves are used in surgical work—rubber and cotton. Thin rubber gloves are most common. Their routine use by anyone appears to indicate that the user will not or cannot take proper care in the preparation of his hands. It is asserted that there is less risk of infection of the wound when the surgeon's hands are covered by such a boiled film —that results are better, the latter statement being the proof of the former. Personally, I can say that my results are no better during the times I wear gloves than at other times. Gloves act as a handicap to touch and manipulation. This is acknowledged by the statement of even the most ardent users of gloves, "that the fingers become soon accustomed and educated to feel through them." Personally, I feel safer, and I feel that the patient is safer, when I introduce my bare hand into the abdominal cavity than when it is covered by a glove—for two reasons: (1) That with all my practice with gloves on and attempts to educate my fingers to become accustomed to them I cannot palpate so well as with my uncovered fingers, and I cannot therefore, for example, separate adhesions with the same assurance. This being so, for safety's sake if I wear gloves, I must make a larger incision in order to bring direct vision to the help of touch. While I think it is unsafe to be hampered by a small incision, I do not believe in making unnecessarily large incisions, and this is, in my opinion, done too frequently by many operators, especially glove users, who seem to simply follow a fashion for which the late von Bergmann appears to be chiefly responsible. (2) There is always the danger, and this is also acknowledged by routine glove users, that, especially during long operations when septicity may have worked out from the pores of the skin, septic matter may escape through an unnoticed puncture in the glove. For this reason some operators wear cotton gloves *over* the rubber ones. Of course, if any puncture is noticed, rational operators will at once put on fresh gloves. Rubber gloves have their most important function in preserving the hands from becoming soiled during operation on, or in dressing or examining, septic cases, during rectal or vaginal examinations, and again in covering the hands if any abrasion or suppurating focus exists on them. In the latter case, of course, one cannot expend too much care in preventing escape of sepsis through the gloves.

Without doubt, students, or other immature or unpractised assistants, form an imminent danger to aseptic healing of the wound, and such assistants should always wear gloves. From the point of view of expense, in justice to contributors to the funds of a hospital, cotton gloves may be used preferably and with equal success, if care be taken. If there is anything in Murphy's idea that protection is offered by the layer of dried blood which collects on the fingers during operation, the blood which coagulates and dries in the meshes of the cotton gloves should be quite impervious. Such gloves should be put on when dry. If soiled they must be changed at once. Therefore it is necessary to have many pairs sterilized for each operation. It is very striking what a difference such a precaution will make in general results so far as superficial healing is concerned. The operator alone should put his hands in the depth of a wound, so that he alone is responsible for what occurs there.

Operators who find that they get better results from the use of rubber gloves *must make routine use of them.*

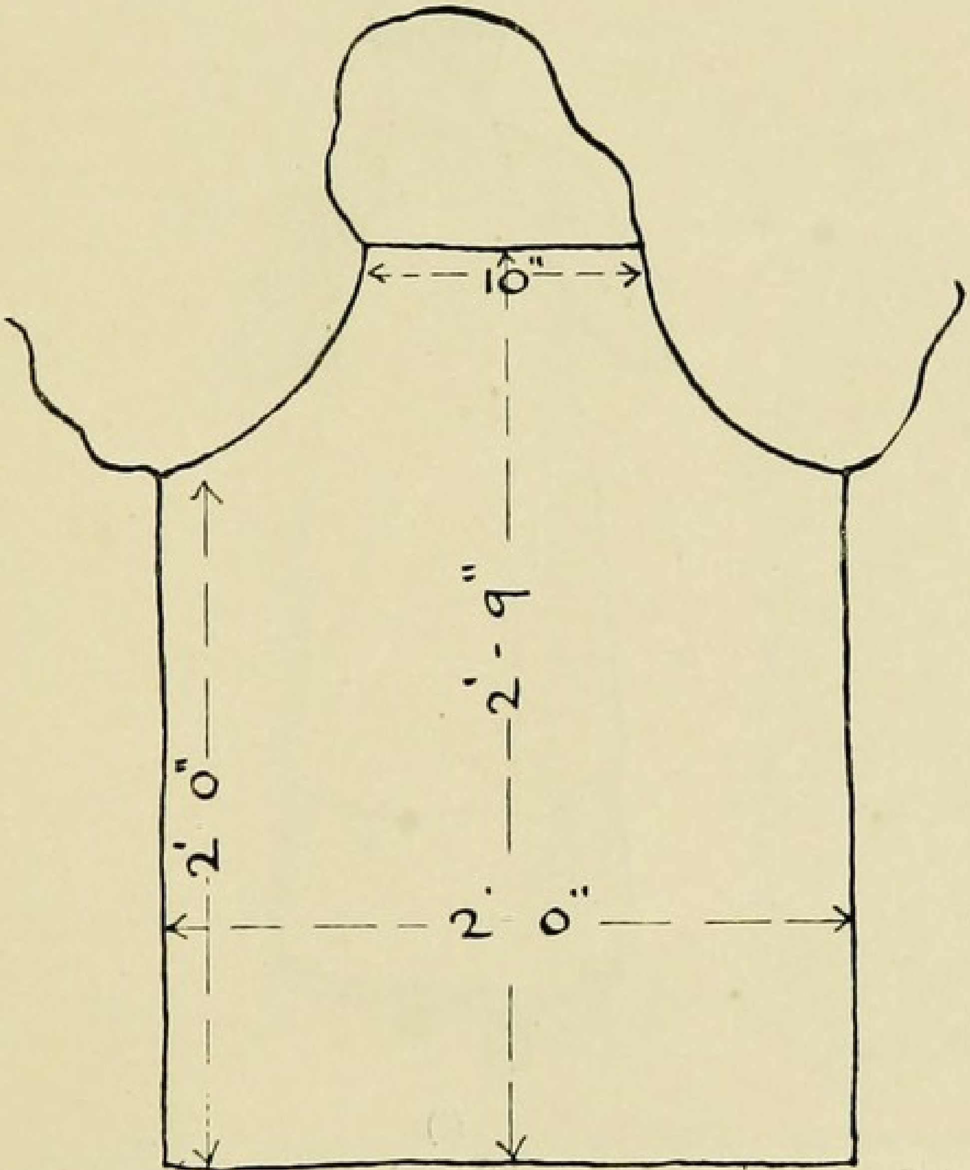
The gloves must be boiled or sterilized by steam before being used—the rubber film will not stand cleaning manipulations like the skin does. Steam sterilization is preferable. Each finger of the glove should be distended with a thin strip of gauze before sterilization is done, so that the steam may reach to the tips of the fingers. Otherwise it is theoretically requisite to employ a temperature greater than the gloves will stand. The gloves are wrapped in gauze or a towel during sterilization and thus need not be handled before they are used. Sterilized powdered talc, boric acid, or some such aseptic lubricant powder is dusted over the dry hand before the glove is drawn on. It is better not to shake the powder into the glove, as by so doing some of the powder falls to the finger-tips and, making a pad there, interferes with the sense of touch. Dry gloves on dry powdered hands preserve the hands best, and are safer on the whole for the patient than when the gloves are boiled and put on wet. If the gloves are boiled the hands should be wet and the gloves filled with fluid before attempting to draw them on. It is difficult to get rid of such fluid—a certain amount always remains under the glove, and this macerates the skin and allows organisms to work out more easily to the surface. If a puncture occurs, infection is very liable to happen because of the escape of infective fluid which takes place whenever movement of the part under the puncture is made. To destroy any such organisms, if possible, the hands and the gloves (after boiling) should be immersed in antiseptic lotion so that the antiseptic which remains on the skin after the gloves are drawn on may deal with the organisms. The maceration of the skin which is entailed by the use of wet gloves tends to make the skin very brittle and difficult to keep clean. One must be careful in putting on rubber gloves that (1) they are not torn; (2) they are not soiled; (3) that all possible fluid be expressed from beneath them. It shows a slovenly appreciation of the utility of gloves when the last point is so neglected that during an operation fluid overflows or squirts from the glove and trickles over the hand into the wound. The gloves are put on in the following way: The mouth of the glove is stretched by two fingers and the glove is filled, by a movement of "scooping," with the antiseptic solution in which the gloves lie. When the glove is bulging with fluid it is held in one hand by the cuff, while the other hand, wetted all over, gently wriggles into it. It will be found that the fingers are easily made to glide into their respective places without having to handle the outside of the glove with the uncovered hand. Then the other glove is filled and put on in exactly the same way. The fingers, if necessary, are further adjusted by stroking with dry sterile gauze. This removes the excess of fluid from the fingers to the palm, whence it is carefully squeezed by suitable manipulations. The glove should fit tightly, but not so as to hamper the movements of the hand.

THE DRESS OF THE SURGEON AND ASSISTANTS AT OPERATIONS.

To be thoroughly consistent, after what has been said, the skin of the *body* should be disinfected, and all clothing, shoes included, as well as the surgical overalls, should be sterilized. For practical purposes most surgeons find this to be unnecessary. An outer covering of purity seems efficient, if a daily bath be taken and the underclothing changed frequently. The most important sources of infection are the hands of the operator and assistants. Most space has accordingly been devoted to their care and treatment.

FIG. 1.—Surgeon in complete costume. Showing the method of tucking up the sleeve without touching the skin of the upper arm.

Overall.—Other paths of infection are more easily excluded—the clothing is covered by a sterilized white linen overall, fastening down the back and reaching at least to the knees. It should fit closely to the neck and should be fastened with tapes. In order to allow of this, and for comfort, the collar and tie should be removed. The sleeves should be wide and reach to halfway down the forearm, so that they may be



(*a*)

FIG. 2.—(*a*) Linen apron—a fresh one put on for a second and each subsequent operation.

firmly tucked up by the *wearer*—without soiling his hands on the skin of his arm—as is shown in the accompanying figure. This tucking up prevents infective material being shaken down from the underclothing or armpits.

Aprons.—In order to do away with the necessity of putting on a clean overall for each operation, linen

(*b*)

FIG. 2.—(*b*) The apron when fastened. It covers the part on the overall which is usually soiled.

aprons may be used provided with a tape sling to go round the neck. The apron is fixed at the waist by two side tapes (fig. 2).

Mackintosh Aprons.—To preserve the wearer's clothing from soap, blood, or discharges, a sterilizable waterproof apron should be put on before disinfection of the hands is begun. This should reach from above the level of the nipples to the boots. It should be slung from the neck by strong tapes, and fastened loosely round the waist by the same means.

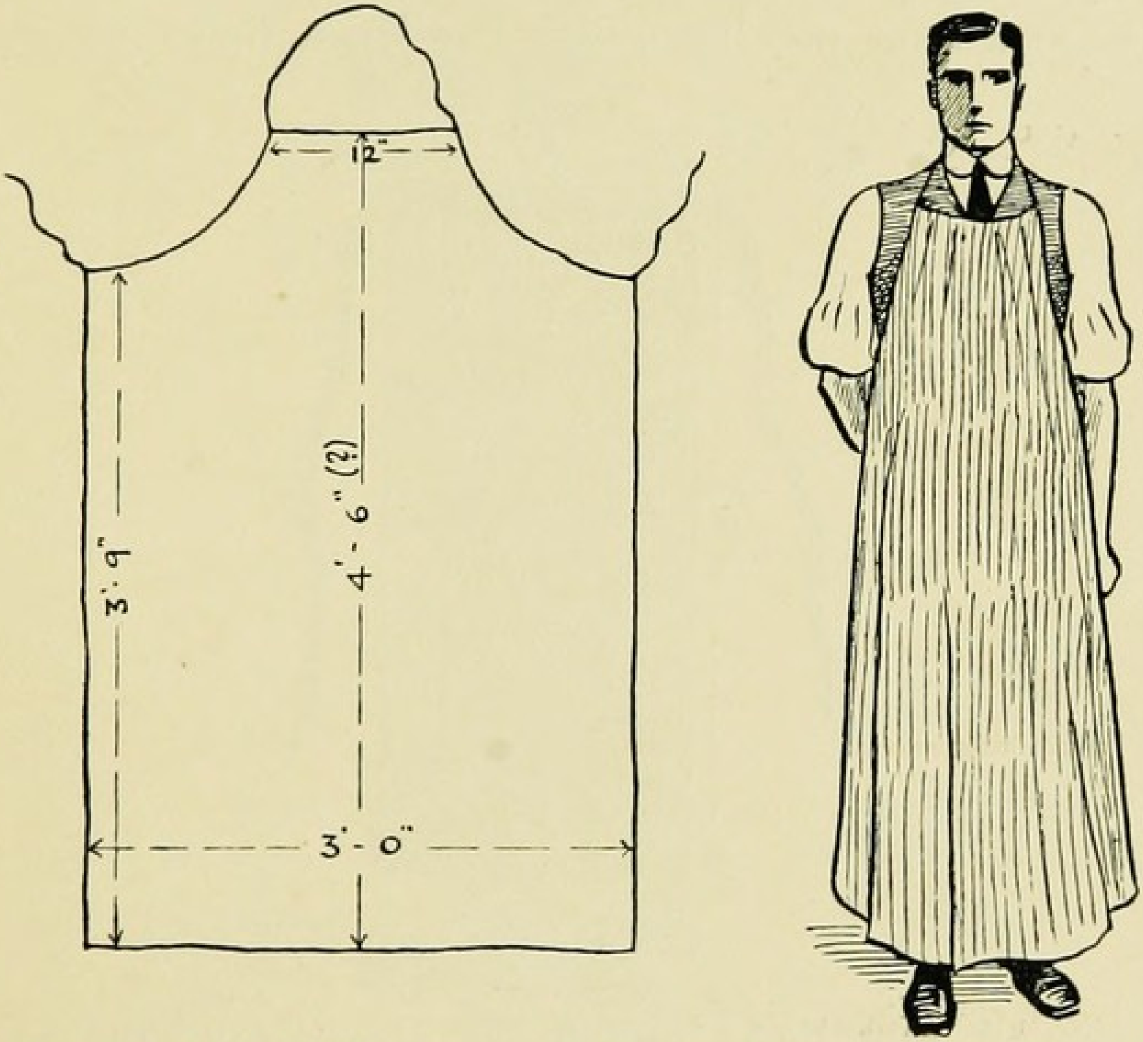


FIG. 3.— Mackintosh apron, to protect the ordinary clothing, put on before disinfection is begun.

It is made, for durability plus efficiency, of batiste or some other sterilizable material (fig. 3).

Caps.—The operator and immediate assistants should wear aseptic caps or other coverings on the head to prevent infective particles falling from the hair into the wound should their heads come in contact during an operation. Caps must be made of some fairly firm material so that they do not require much manipulation to put them on. They must be made to fit the person with the largest head, or else must be labelled with each person's name. Loosely fitting caps are only a degree better than none at all. The writer and his assistants use triangular bandages (base 32 in.),

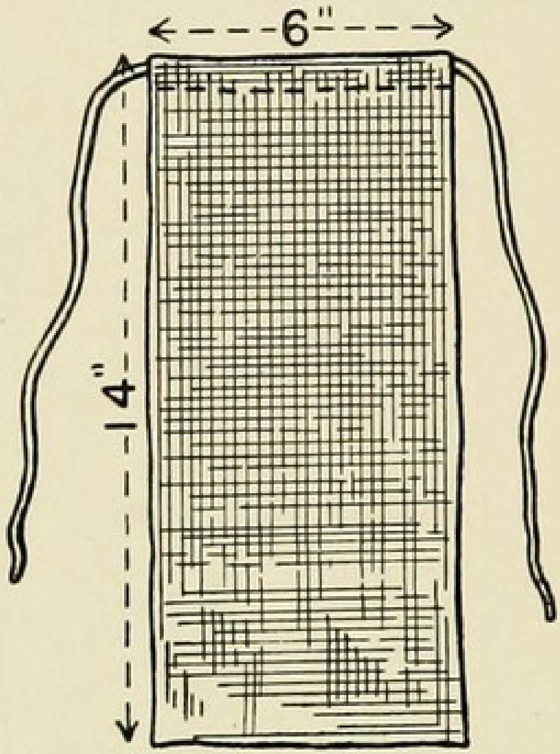


FIG. 4A.—Mask.

made of fine lawn, which are placed over the head by the wearer; and then tied under the occiput by a nurse, in the manner shown in fig. 4B for the mask.

Masks.—One of the simplest and coolest forms of mask is made of four folds of ordinary dressing gauze 6 in. by 14 in., turned in and stitched at the edges, and provided with tapes at one end. The mask is put in position by the wearer, and then the tapes are tied by the nurse—as shown in fig. 4B. It is best to put on the mask before the overall. This obviates the necessity of pushing the lower end of the mask under the neck of the overall, which cannot be done without soiling the fingers.

FIG. 4B.—Method of holding mask (or cap), so that the nurse may catch and tie in position without touching the disinfected hands of the wearer.

These masks are worn in order to prevent particles of sputum being projected into a wound, if the operator or assistants speak or breathe heavily during an operation. That this is a source of infection can be easily proved experimentally by speaking over a culture medium exposed in a Petri dish. The cultures obtained vary in number according to the manner of speech of the speaker. Some masks in use are hot, uncomfortable, and unhealthy for the wearer, especially if worn for hours on end. This is particularly the case when mask and cap are combined in one piece which envelopes the whole head and neck, leaving only an aperture for the eyes.

Shoes.—Some operators wear strong rubber shoes

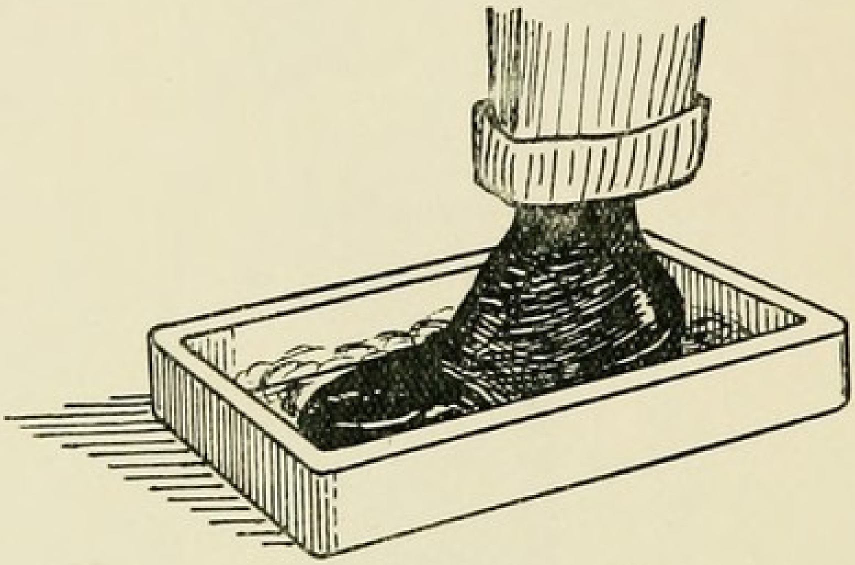


FIG. 5.—Shoe dip.

over their boots, which are put on before the theatre is entered. This is done both to prevent filth being disseminated on the theatre floor and to protect the boots. The latter function is not so necessary in these days of dry operating.

Shoe Dips.—With the former object in view, a better plan, to my mind, is to saturate the outside of the boots with some such antiseptic as 5 per cent. formalin before entering the theatre. This can be done in an easy and simple way by having, outside the door of the theatre, a small trough, measuring 14 in. by 6 in. by 2 in., made of zinc or stoneware, which is filled with cotton-wool saturated with the formalin solution (fig. 5). The cotton-wool should prevent the solution

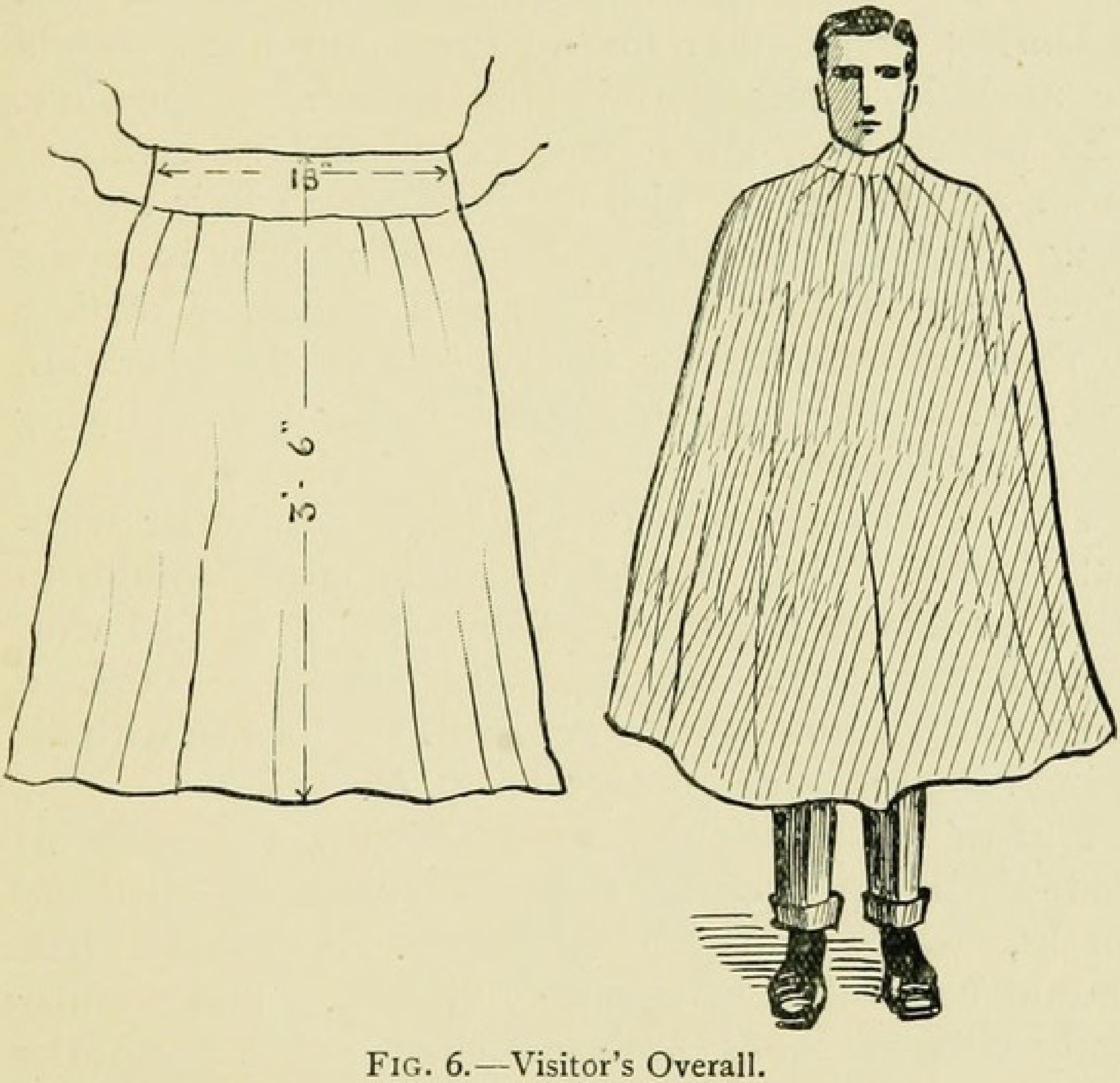


Fig. 6.—Visitor's Overall.

from being accidentally spilt, and at the same time, when the foot is pressed down on it, the solution should well out of the wool and moisten the surface of the sole and lower part of the boot. The formalin does not destroy the boot leather and acts as a strong disinfectant. The dip should be used regularly before entering the theatre, and immediately after leaving it also if any septic material has been spilt on the floor. It is extraordinary how little precaution is taken to prevent the carrying of such infection to the wards by the feet. It has been experimentally proved that infection may be carried hundreds of yards in this way.

During preparation for an operation there should be as little commotion in the theatre as possible. The jacket, vest, collar and tie should be removed in an ante-room. If visitors are allowed they should wear sterilized overalls, and should remain in some place appointed for them. It is a source of anxiety to those responsible for the success of the operation when an unskilled and inquisitive visitor keeps moving about the theatre.

Visitors' Overalls.—Visitors' overalls are better without sleeves. They should be made large enough to hang loosely to the knee. They should be tied with tapes at the back. An attendant should be deputed to prevent visitors gaining access to the theatre without being robed in such an overall (fig. 6).

Nurses' dress should be practically the same as that of the operator with the exception of caps and masks, which are not necessary. A nurse's hair should be neatly and smoothly dressed. The popular fluffy coiffure looks unbusinesslike and is surgically incorrect.

CHAPTER II.

THE OPERATING DEPARTMENT.

In large hospitals this consists of a theatre and several ante-rooms. In smaller establishments these ante-rooms are dispensed with, but in even the smallest cottage hospital it is very desirable that at least a sterilizing room should be available besides the theatre, because after an operation the theatre should be cleaned at once, the door shut, and no use made of it until it has to be prepared for the next operation. The preparation and sterilization of dressings and utensils should be done in a special room, access to which should be prevented unless under stringent conditions. Briefly, there should be, besides the theatre, an anæsthetizing room, a room for disinfection, a sterilizing room, and a small room or passage for visitors to change their clothing and wash. In large hospitals, where possible, each surgeon should have his own special operating department in connection with his wards.

In order to satisfy modern aseptic requirements the theatre floor, walls, and roof must be smooth, with rounded corners at floor and ceiling, capable of rapid and thorough cleansing, and not liable to crack.

Theatre Floor.—The floor is made usually of large white tiles, very accurately laid, or of terrazzo. The floor should be sloped, preferably to an open gutter at one side of the room, so that the fluids will run off easily. This gutter should be carried through the wall, at least into an adjoining room, better to the outside where the fluids conveyed by it should fall into an open pipe, efficiently trapped at the foot. There should be no direct connection of theatre or waste pipes with the drain pipes.

Walls.—The walls, for 4 to 7 ft. up, are lined usually with the same material as the floor. This is unnecessary in small places where there is not much work. The remainder of the walls and the roof is covered with impervious plaster or cement which when coated with white enamel paint can be cleaned by steam hosepipe without detriment. The paint should be renewed when necessary. The windows, preferably double with a large space between, are best to be made flush with the wall so that no window sill is left. Double windows keep the room much warmer. The wider the space between the windows the more efficient is the air jacket, thus provided, in keeping up the temperature. In some theatres the space is so wide that a man can pass along in order to clean the glass, &c.

Ventilation.—The heating apparatus may be placed *in* the wall immediately below the windows and separated by a grating from the interspace. *Heated* air thus fills the space between the windows. This arrangement does away with the necessity of having exposed radiators or of heating the theatre by the cumbersome and often unsatisfactory plenum system which has been so frequently used. It also prevents condensation of vapour on the glass, so obvious in some theatres. Air gains access through a filter of gauze, wire netting, and cotton-wool, properly protected, in the outer wall. It passes over the heating apparatus (steam or hot water radiators) through another thin filter into the theatre. The stream of air may be accelerated when desired by an electric fan placed on the theatre side of the filters. The fan and filter openings must be protected by a sliding door, or some such arrangement, during the hosing-out process. Vitiated air is drawn off through efficient openings, one near the roof, another near the floor in order to cause a slight draught there so that heavy gases, such as ether, may be at once sucked away. Such openings should be provided with a filter to prevent dust falling into the room, and the flue with which they are connected should have a gas flame burning in it continually during the time the theatre is being prepared and used for operation, or a fan may be placed at the top of the common shaft. All air filters are to be renewed or cleaned periodically.

Temperature.—The temperature of the operating theatre and disinfection room during operations should be about 70°—75° F., especially when abdominal, thoracic, or cranial operations are in progress.

Windows.—The windows (see also under *Walls*) of the theatre should be extensive, lofty, and the outer one, either entirely or in part, made of obscured glass. If the shape and position of the theatre allows, the windows are best arranged so that light is thrown from three sides, or from a semi-circle. The windows should be protected from the rays of the mid-day sun, hence, north of the Equator they should look north-east. Roof light is unnecessary and undesirable, unless very thorough arrangements are made to prevent leaking in rainy weather and condensation at any time. The sheets of glass should be as large as possible, and the inner panes, at any rate, with their supporting frames, should be made flush with the theatre wall.

No Fixed Furniture if possible.—There should be as little fixed furniture as possible. There really need be none in the theatre of a large hospital where numerous ante-rooms are attached. Two to four wash-hand basins are advisable, however, for use during operation. These basins should be fixed at the side of the wall where the gutter runs. All the other furniture, operation table, tables for instruments, basins, anæsthetics, should be provided with large ball-bearing pivoted wheels, rather than castors, so that they can be moved about by the slightest touch.

Operation Table.—The operation table should be simple so that it may be easily cleaned. Nowadays it is practically always made of metal. Stability combined with easy mobility are essentials, therefore some lever or screw arrangement should provide that all *four* wheels may be put out of action. The foot of the legs should have a rubber pad to prevent slipping on the smooth floor. If the temperature of the theatre is such as to prevent the patient losing much heat, hot water tanks or pipes on the table are unnecessary: otherwise some such arrangement for maintaining the body heat of the patient is very desirable. One must remember that burns are very liable to occur from an overheated table, especially if the anæsthetized person is in a weakly or septic condition. The table should allow (1) of the inversion (Trendelenburg) position, permitting *rapid* replacement, when necessary, to the horizontal; (2) of raising the head and shoulders; (3) of the gynæcological position, the leg-rests being removable. Head rests, props for liver or kidney operations and other accessories can be adapted according to the practice and taste of the surgeon. Any instrument makers of repute can furnish such a table, of their own pattern, which will be quite satisfactory.

Large Table for Basins.—There should be a large table for holding basins, &c., near the supply taps for

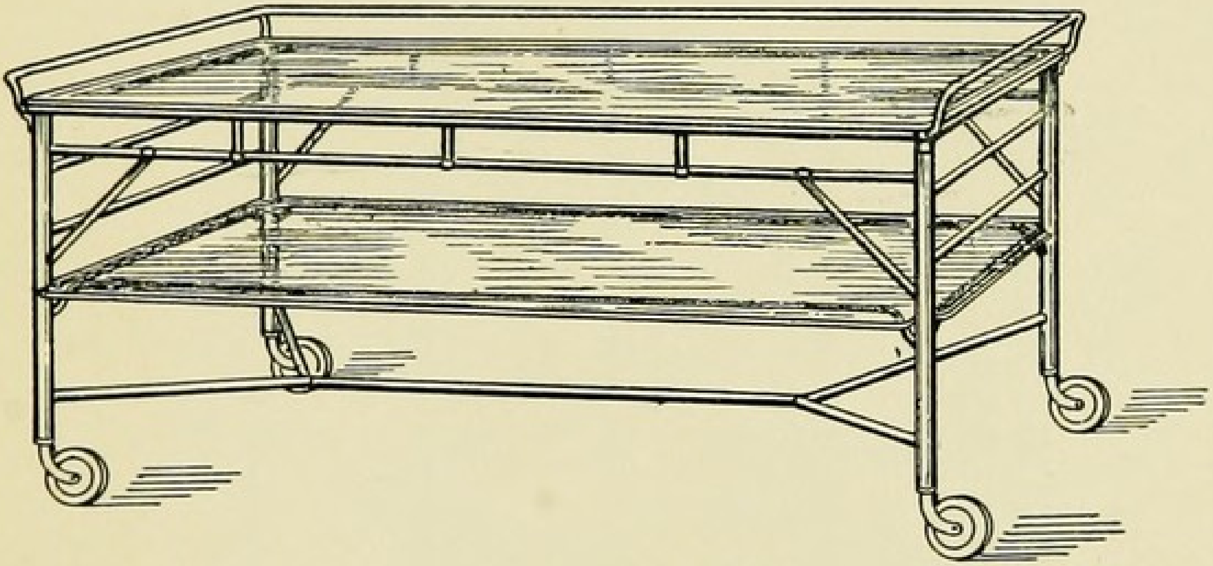


FIG. 7.—Large table for basins, &c., to stand at one side of the theatre.

hot and cold sterile water. These taps must, of course, be placed at some distance from the wash basins. This table should be 4 to 6 ft. by 2 ft. and should be provided with an under shelf. Both table and shelf should have a low rail round them (fig. 7).

Instrument Table.—The instrument table is usually made curved (fig. 8). It is best provided with a low rail ($1\frac{1}{2}$ in. high) round the top. The boiled instruments are laid on a sterile sheet and covered until wanted with a sterile towel. A basin holder, a simple ring of thick metal, is fixed to a leg of the table at each end. The arm of the holder is made long enough to carry the basin quite clear of the table and so bent

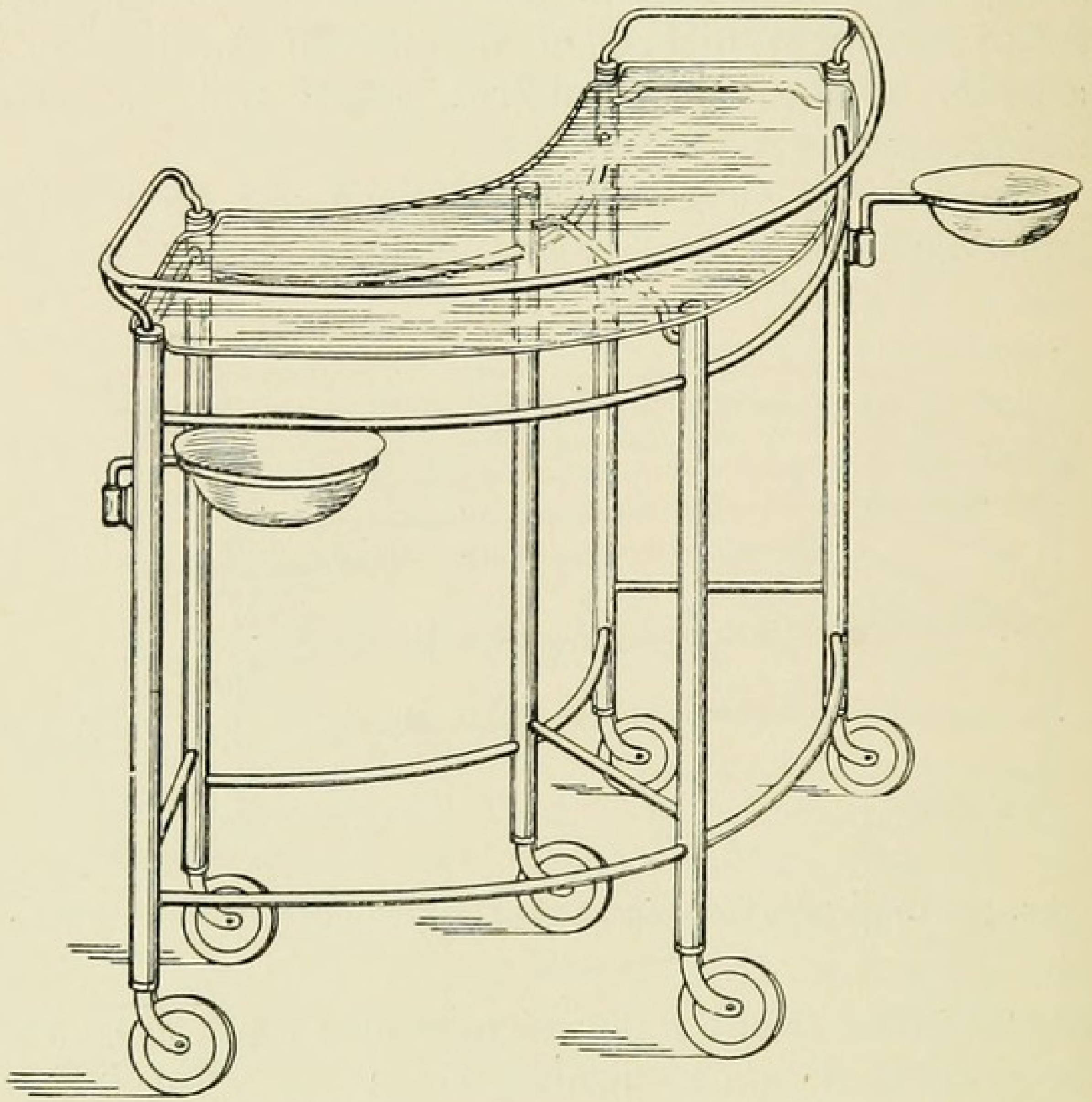


FIG. 8.—Table for instruments.

that the hinge will allow the ring to be swung under it when not in use.

Anæsthetist's Table.—The anæsthetist's table is also provided with a second shelf and surrounded by a rail about 3 in. high for the safety of bottles (fig. 9).

Accessory Instrument Table.—Some operators use a small table on which to have instruments more easily within reach during operation, and to prevent them being knocked on the floor by movements of the patient. They are cumbersome, and unnecessary when

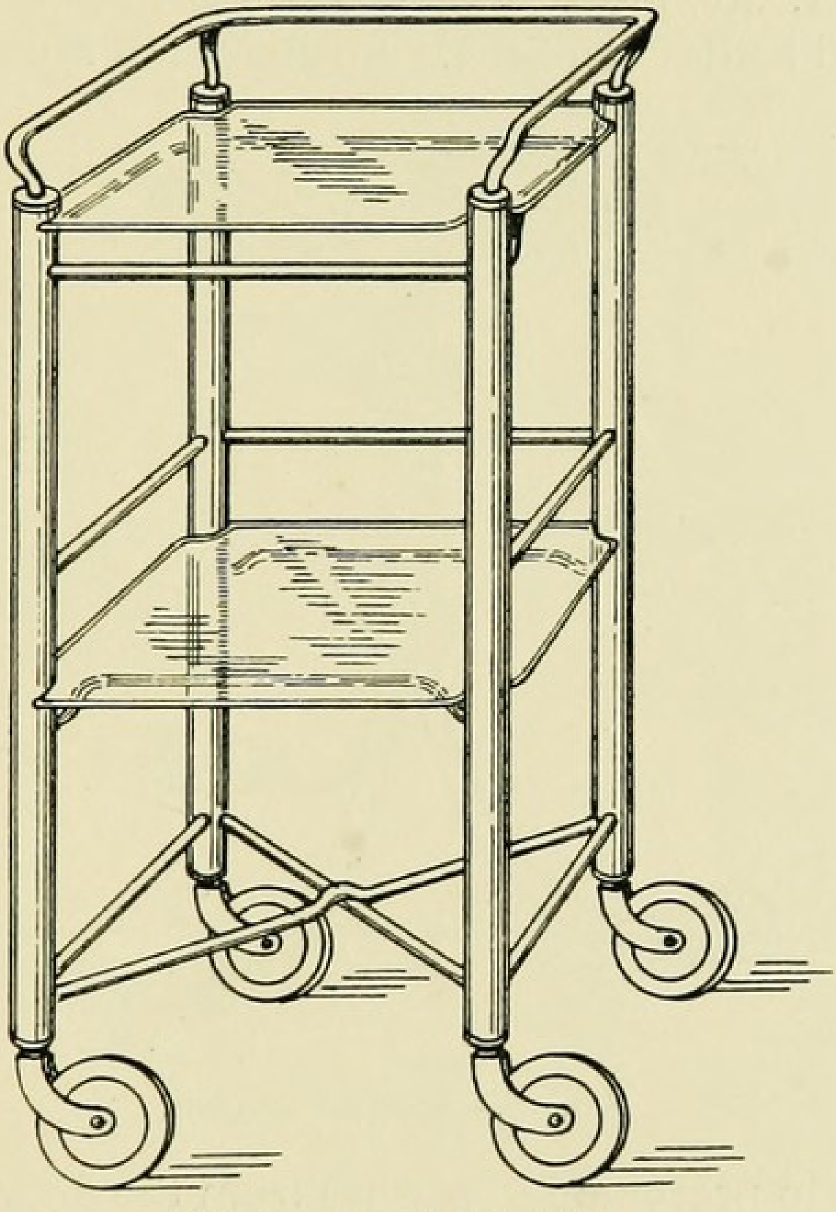


FIG. 9.—Anæsthetists' table.

the anæsthetist does his work properly. Most operators prefer to lay such instruments as are most frequently wanted on the sheets covering the patient.

All these tables should have thick glass or metal tops.

Stools for Operator, Anæsthetist, &c.—The stool for the operator should be made so that it will screw down very low, for convenience during certain operations, for example, on the perineum (fig. 10).

Frames for Sterilized Drums.—Frames, such as shown in fig. 11, are most suitable for holding the various sterilized kettles required. Such frames must be high

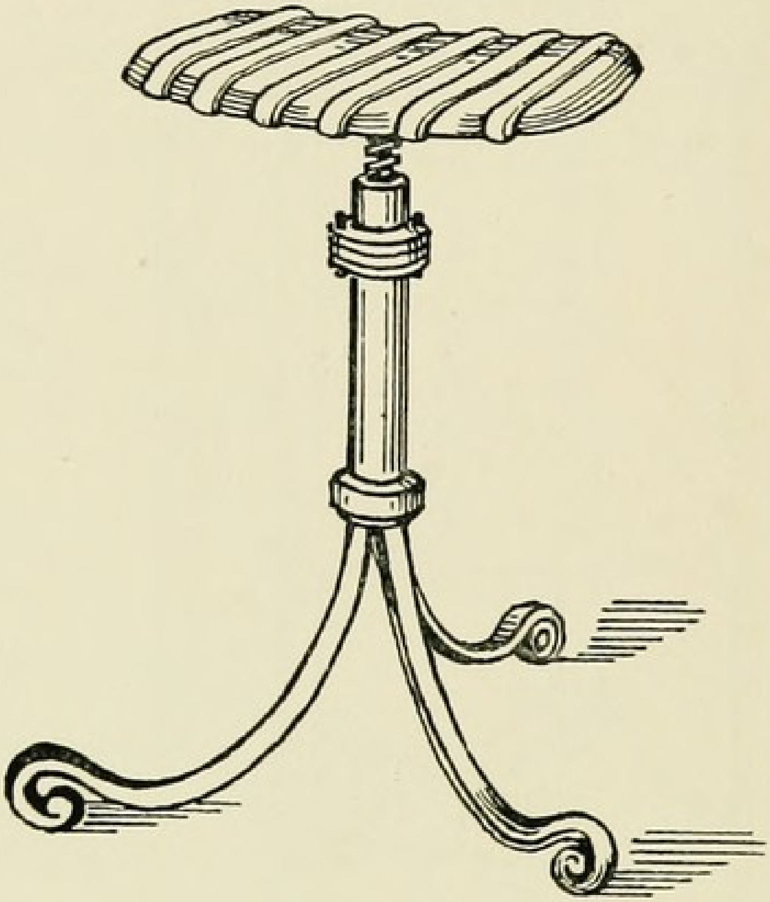


FIG. 10.—Stool for operator.

enough to prevent any splashes from the floor reaching the kettles. The number of such kettles and their contents wiil be discussed later.

Irrigators.—There should be two irrigators, slung from the roof, placed usually one at each side of the foot of the operation table and distant 3 or 4 ft. from it in such a position that any accidental drip will not fall on anything of importance. (A good type of irrigator is that known as Harrison Cripps'.) The cord slinging it to the roof should be impregnated with celluloid or some waterproof material. The

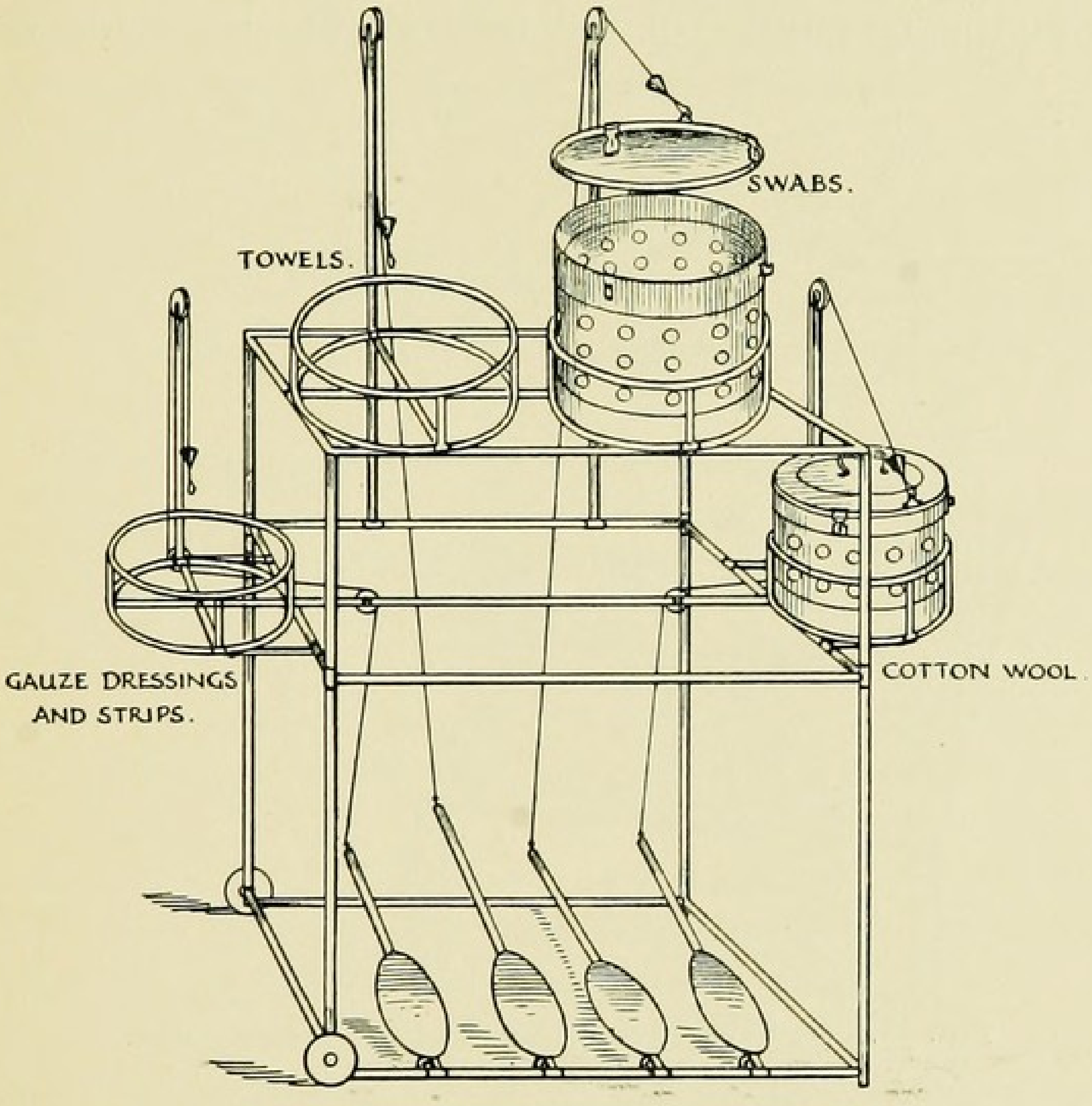


FIG. 11.—(*a*) Frame for "kettles" or "drums," showing pedal arrangement for opening lids.

pulleys should be simple and open in construction so that they can be readily cleansed. The irrigator and rubber tubing should be sterilized *en bloc* before any operation in which irrigation is likely to be required; otherwise the sterilization should not be done, as the rubber tubing usually supplied deteriorates very soon from repeated boiling. The part of the supply tubing near the nozzle should be detachable so that it can be at once sterilized when soiled. This detachable part, should be at least 4 to 6 ft. in length and the joint with the remainder of the tube should be made of

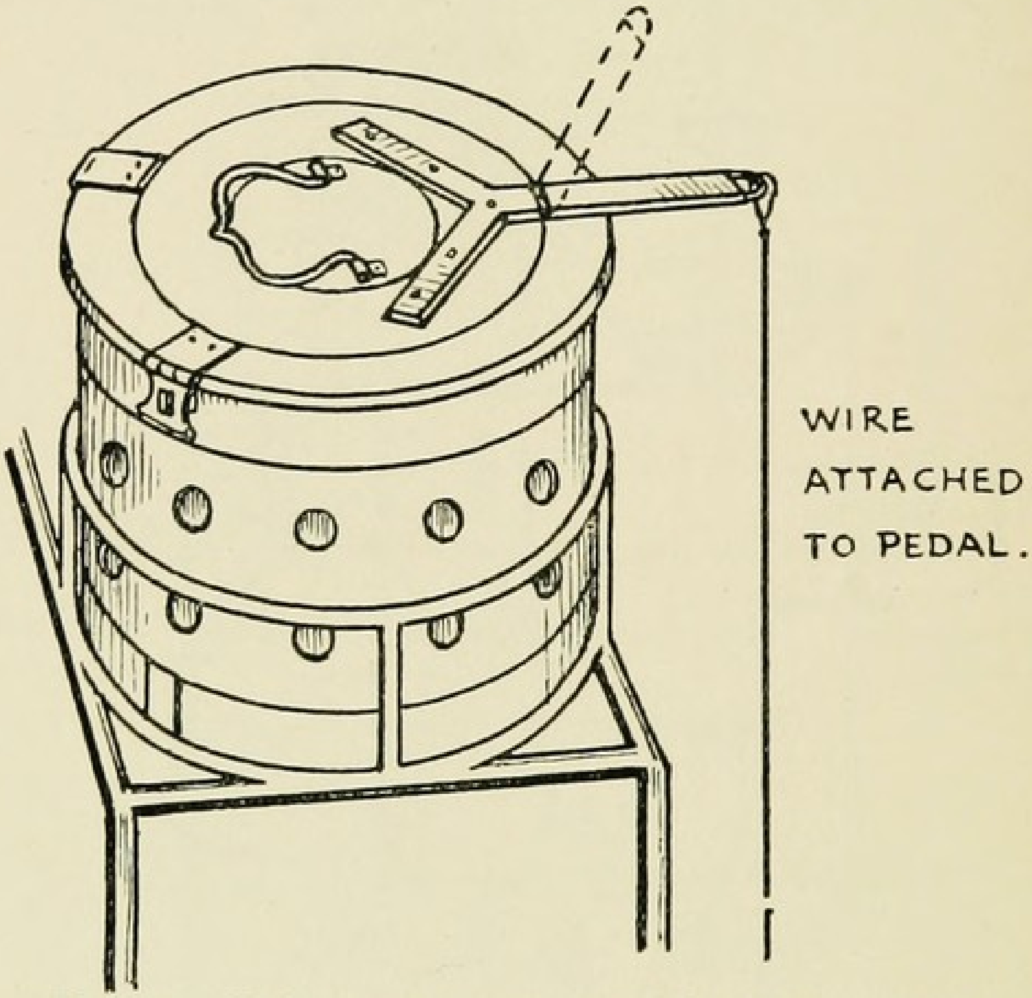


FIG. 11.—(*b*) Alternative arrangement for opening drums.

metal. Irrigation is seldom used now, but provision should be made so that when it is considered necessary, it will be efficient.

Supply of Sterile Lotions, &c.—Antiseptics, except in the preparation of the surgeon's hands or patient's skin, are discarded by most. Therefore the long array of lotion bottles which used to be so familiar is now absent. One may say here that, so far as possible, all fluids used during operations should be supplied in the theatre from taps connected with reservoirs on the other side of the wall. In some large establishments where there are several theatres, there is, at a level above the highest one, a sterilizing room which contains sufficiently large tanks for the supply of reliably sterilized hot and cold water and salt solution to all the theatres. It is probably a safer, therefore a better arrangement to have a special supply for each theatre, in the sterilizing room. In this way the surgeon has more direct control of what is supplied for his use.

In all cases the only parts of the supply pipes which should appear in the theatre are the terminal delivery parts, taps and jets, which should be brought through the wall at suitable places. These parts from the hot and cold tanks should be provided with a tap arrangement or mixing-box, which will enable the hot and cold water to be blended to such a temperature as is required.

Disposal of Soiled Linen.—There must be suitable means of disposal of soiled linen and washable swabs. One of the best arrangements for soiled linen is to have in one of the walls, preferably of the disinfection room, an opening which communicates with a shoot down which towels, &c., are thrown, and are received in a receptacle at the bottom. The opening in the wall is closed by a door which is flapped downwards by a foot lever (fig. 12). This arrangement can be made common to all the theatres, especially if these are placed one above the other. It is almost superfluous to say that this shoot must be extremely well

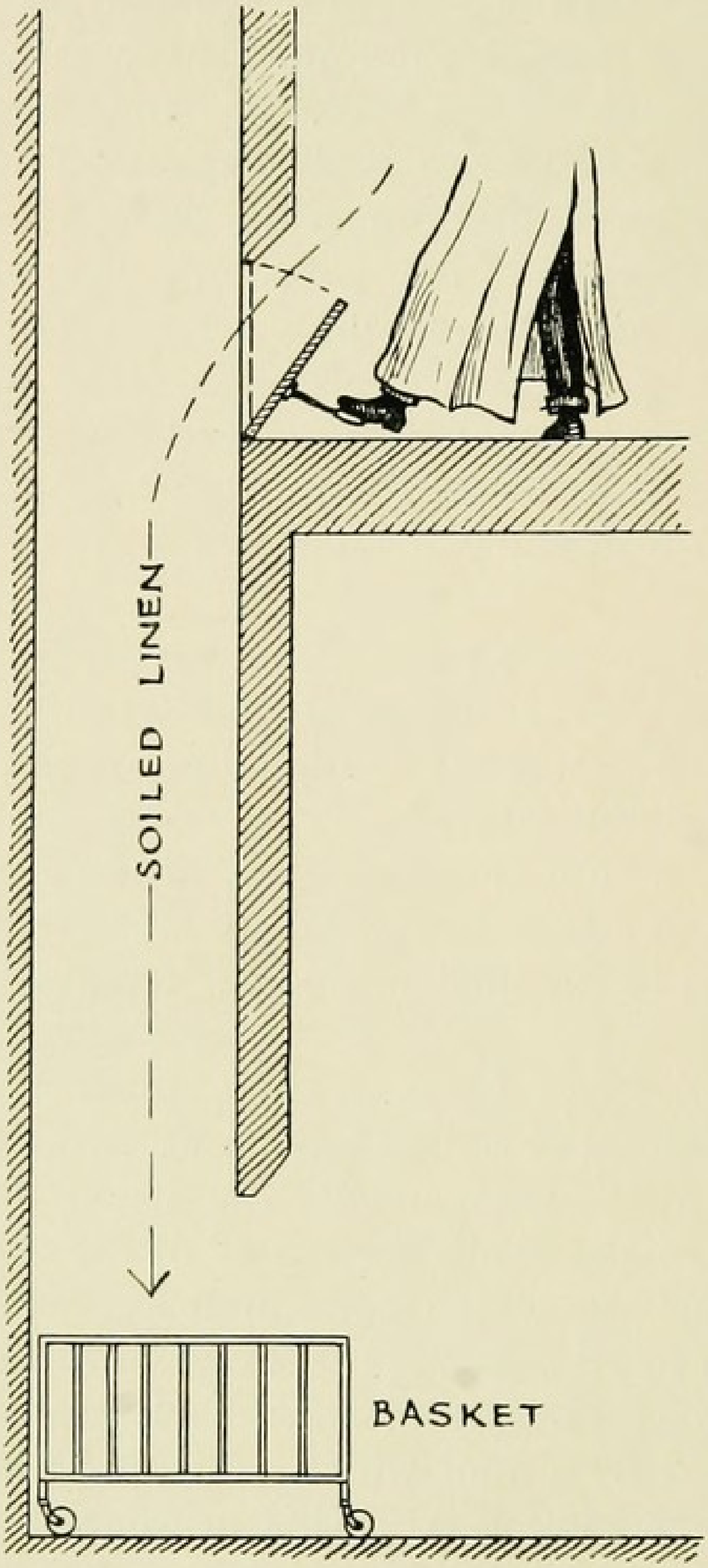


FIG. 12.—Arrangement for disposal of soiled linen.

ventilated, and accessible for cleansing purposes, and that the linen must be removed and soaked as soon as possible.

The alternative arrangement is to have a tank on ball-bearing wheels, in which is a weak solution of ammonia, and into which soiled swabs or towels are thrown (fig. 13). The ammonia allows the blood to be

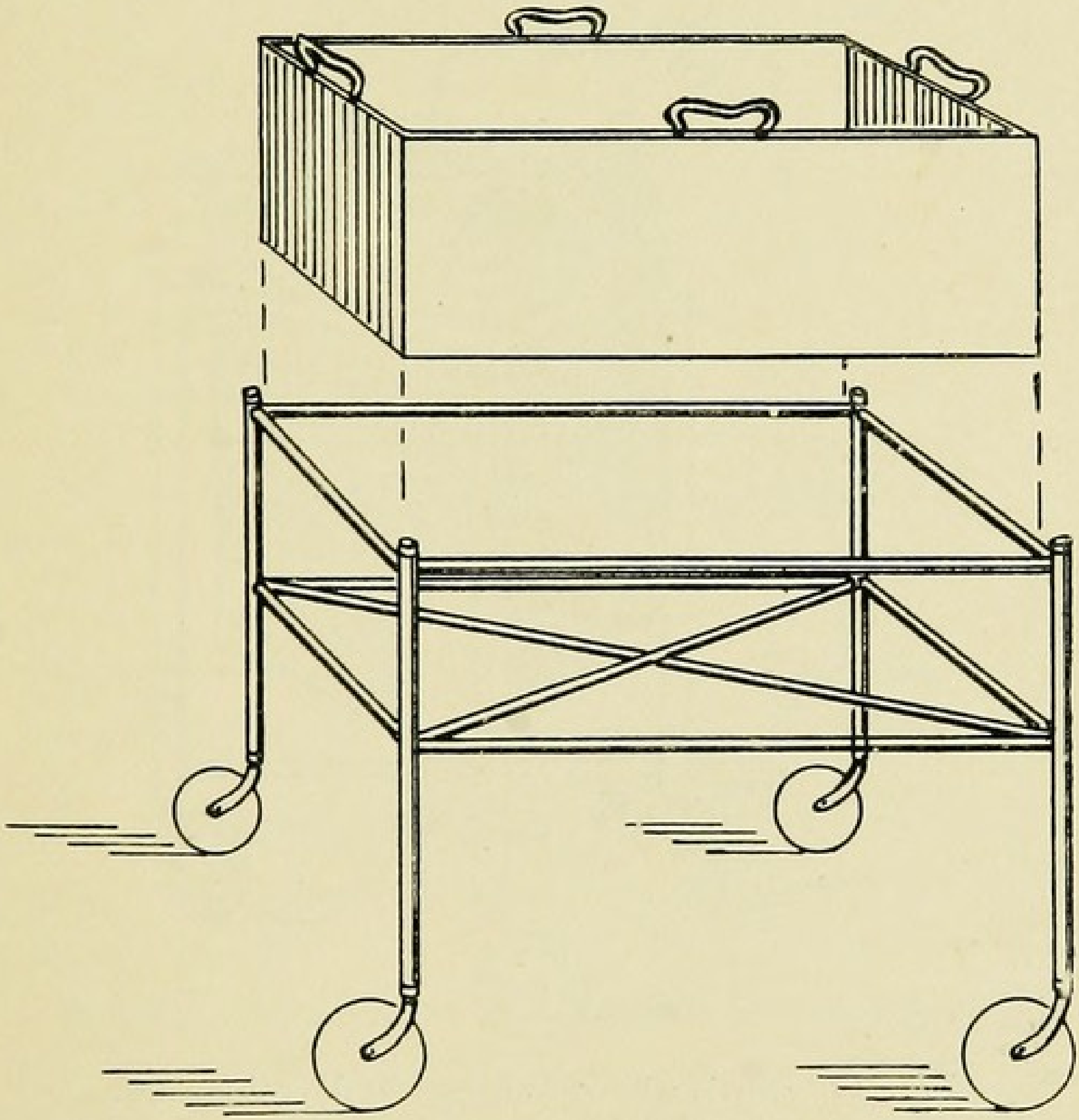


FIG. 13.—Tank for soiled linen.

easily removed during washing. Dirty dressings removed in the theatre or anæsthetizing room should be placed in another receptacle, such as that shown in fig. 14. The canvas bag should be sterilizable.

Fixed Basins.—All fixed basins for disinfection of the hands should be of such a depth and length that the forearm and hand together can be comfortably immersed. The basin and top should be in one piece, with all corners widely rounded. The jets should be bell-mouthed or provided with a spray rosehead, so

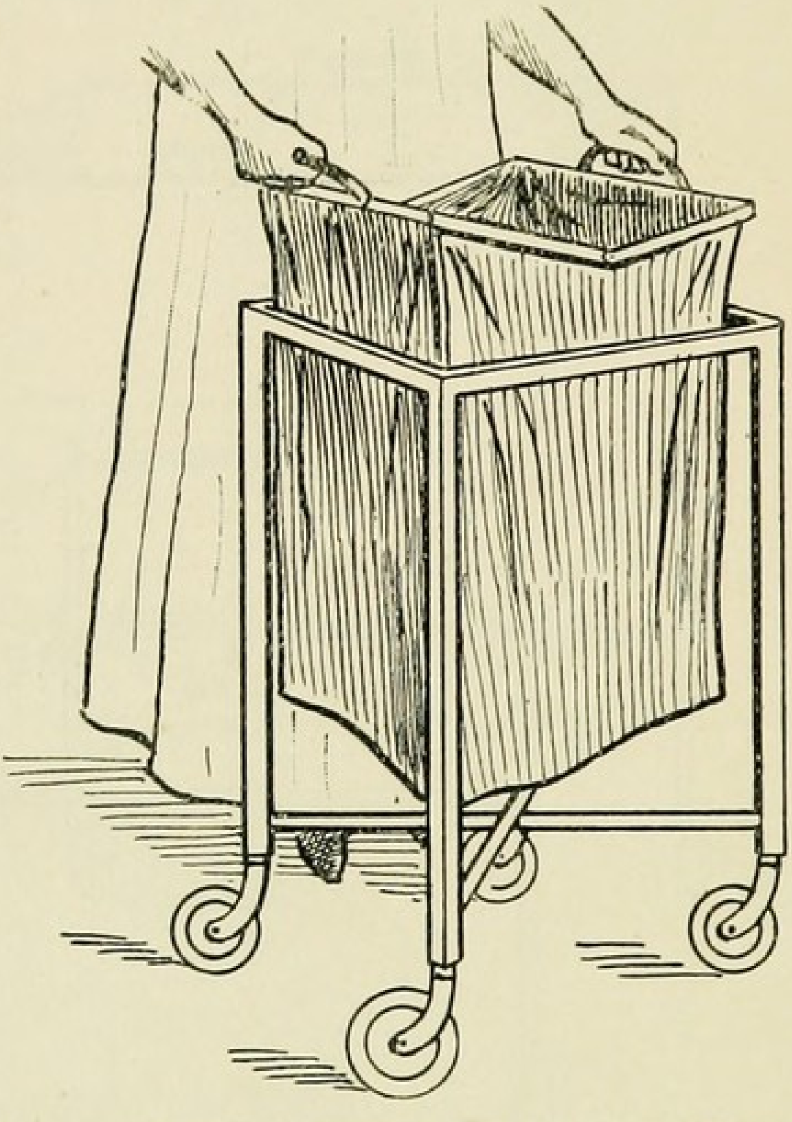


FIG. 14.—Sterilizable canvas bag for dirty dressings.

that splashing is prevented, and should be at such a height and project sufficiently over the basin that the hands and forearms can be flushed with water without danger of coming in contact with either basin or tap.

Taps.—The taps to control the flow of water are worked by hand, elbow, or foot. "Elbow" taps are not suitable where several basins are placed close in a row. They should really be worked by the upper arm, and are as good as any when single basins are used. Where hand taps are used a key should be kept, sterilized, which fits over the ordinary stop-cock,

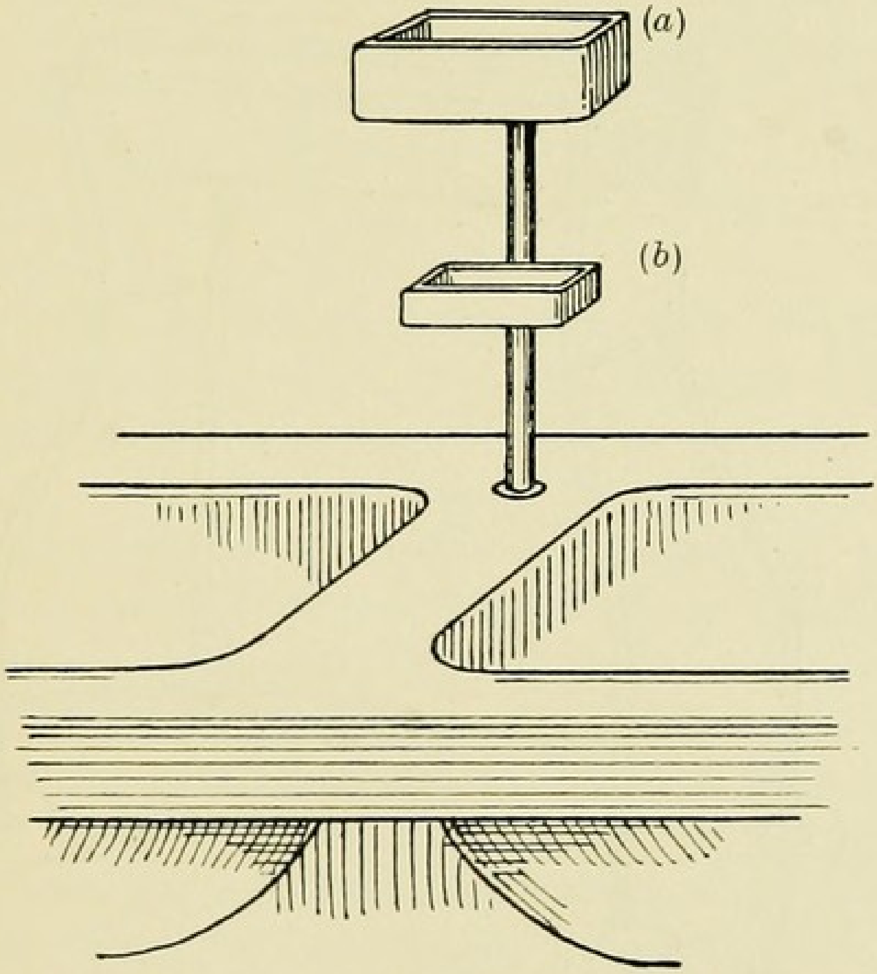


FIG. 15.—Receptacle for (*a*) nailbrushes, (*b*) turpentine soap.

and is used *only* after the hands are sterilized. Foot taps must be strongly made as they are apt to go out of order.

The wash basins in the theatre should be supplied with sterile hot and cold water.

Receptacles for Soap and Nail-brushes.—In connection with the basins there should be receptacles, removable and sterilizable, for holding liquid soap and sterile nail-brushes. These should be placed about 12 in. above the level of the basins so that their contents are not soiled by splashes. This can be arranged by having both receptacles on one stalk, so to speak, which fits into a hole at the back of the partition between two adjacent basins (fig. 15). The

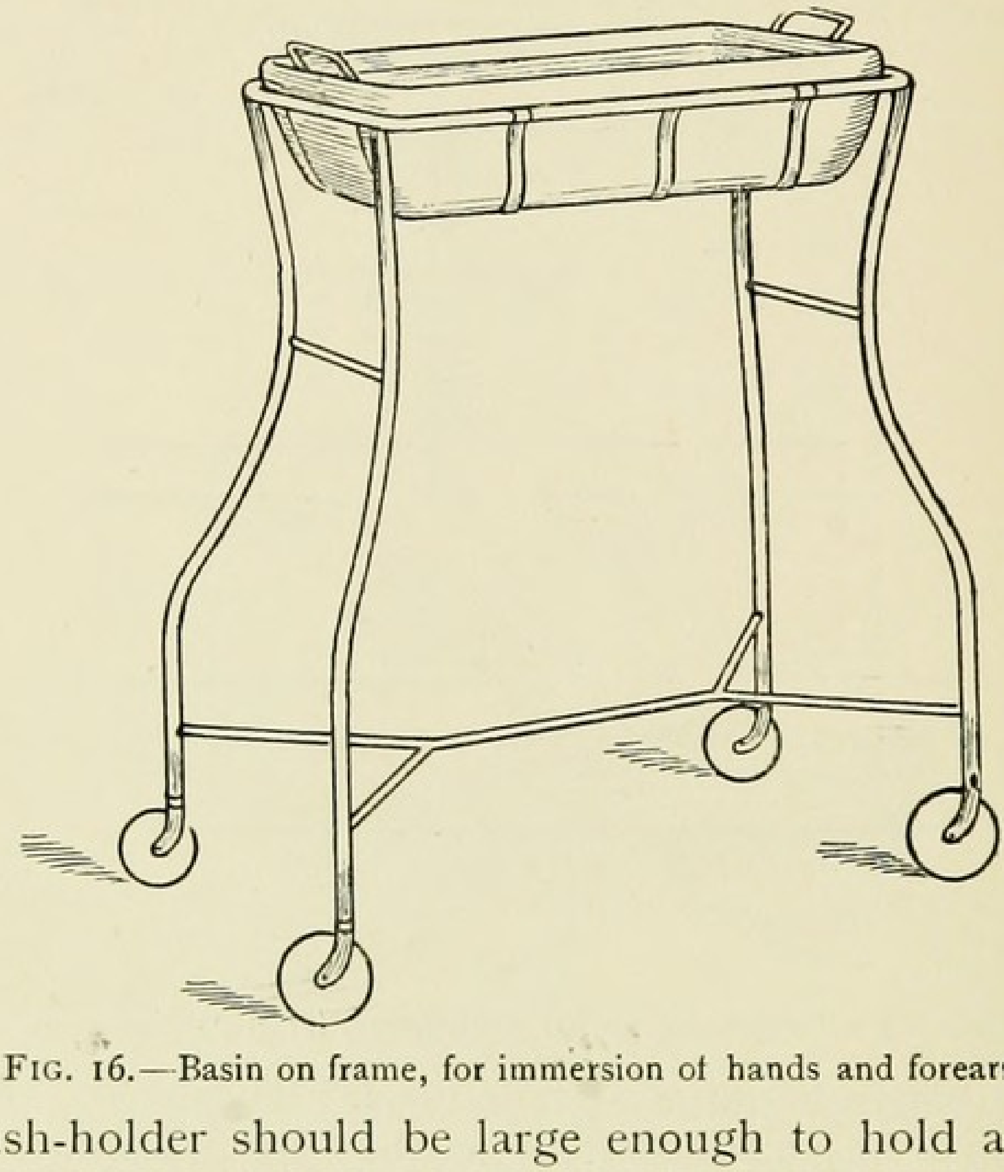


FIG. 16.—Basin on frame, for immersion of hands and forearms.

brush-holder should be large enough to hold at least six brushes, while the soap-holder, placed on the stalk at a slightly lower level, should be shallow and of such an area that the brush can be easily dipped into it on the flat. When ethereal soap is used it must be contained in some form of bottle to prevent evaporation.

Herein lies an advantage of the equally efficacious turpentine soap. Another receptacle (cage basket) should be hung below the basins in such a position that soiled brushes can be easily thrown into it and readily removed for reboiling.

Table for Hand Basins.—A small table or frame (2 ft. 6 in. high) carrying basins filled with antiseptic solutions, should stand at a little distance from the fixed basins. The hands, after thorough scrubbing in running sterile water, are soaked and scrubbed in these solutions. The basins should be of such a size and depth that both forearms and bands can be easily immersed in the solutions (fig. 16).

In addition to the foot-pan placed at the entrance to the disinfection room, it is well to have a piece of felt (stiffened with a strong wire down each side) about 6 or 8 ft. long, and as broad as the theatre door, placed in front of the theatre doorway so that the trolley or table on which the patient is wheeled into the theatre passes over it. The felt is soaked with weak formalin solution. If porters are allowed entrance to the theatre, their shoes are wetted with the solution, while the wheels of the trolley are similarly wetted, both on access to and egress from the theatre. This mat acts as an additional guard against persons who may forget to dip their shoes in the foot pan.

Gallery for Onlookers.—Where many onlookers have to be provided for, there should be a simple gallery, in tiers, the lowest tier being about 2 to 4 ft. above the floor. Each succeeding tier should be at least 18 in. higher than the one beneath it. They should have elbow-rests and very narrow seats. The space below the front elbow-rest should be filled in, the other spaces may be left open. The tiers should be narrow, not more than 20 in. broad, and they should not be more than three in number, so that the whole stand does not project much into the theatre. Frequently a large mirror is hung above the operating table and tilted so that the field of operation is reflected towards the onlookers. These look into the mirror and thereby see what is being done far better than they can possibly do by attempting to crane over the

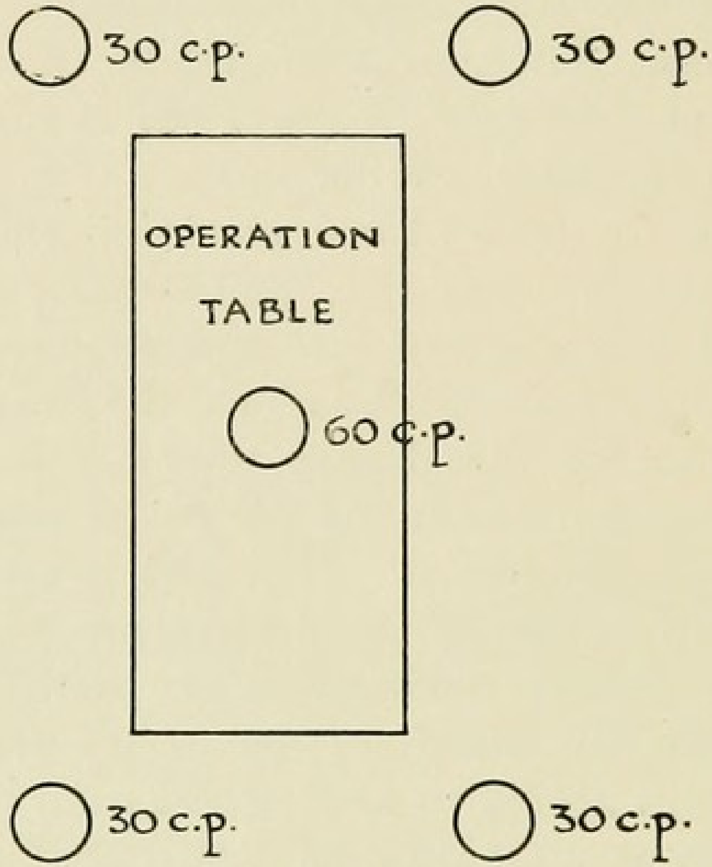


FIG. 17.—Scheme for artificial light.

shoulders of those immediately surrounding the table. Visitors should have access to the gallery by a separate swing door with spring hinges.

Artificial Light.—In most theatres artificial light is provided by electric or incandescent lamps suspended from the roof. The lamps, without shades, should be arranged in some such way as that indicated in the accompanying diagram (fig. 17). By this arrangement a minimum of shadow is cast on the field of operation. The centre lamp should yield the strongest light. A satisfactory arrangement is to have the central light of about sixty candle power, and each of the four corner lamps of thirty candle power. The lamps must be hung about 8 to 9 ft. above the floor. In some theatres they are set on frames which can be pulled or swung aside during the day. This is unnecessary. The lamps can be cleaned daily without damage if care be exercised. It is doubtful whether more modern and expensive methods of lighting are more satisfactory than the simple arrangement here described.

DISINFECTION ROOM.

The disinfection room should be adjacent to the theatre, in fact, it may quite suitably form part of the passage along which patients are brought from the wards to the theatre. It should be wide enough to prevent any crowding during transport of the patient from the anæsthetic room. The floors, walls, roof, and windows are of the same construction as those of the theatre.

Hand Basins.—The hand basins (at least four in number) are arranged in a row on one side of the passage. There should be plenty of elbow-room between each. They should be of the same dimensions and have the same appliances in connection with them as the basins in the theatre. Where the water supply to the hospital is a pure one, it is not necessary that the hot and cold water to these basins should be sterilized. It will save a considerable amount of storage room if only the basins in the theatre, where the final scrubbing of the hands should be done, are supplied with sterile water.

Sink for Washing Instruments.—At one end of the disinfection room may be placed a sink, with a spray jet, for washing instruments (fig. 18). At one side of this tank should be a dripping frame which will hold the trays (of which there should be several) of the instrument sterilizer. After being rinsed the instruments are sterilized and then either taken back to the theatre or dried and stored in the cupboards, if operations are finished.

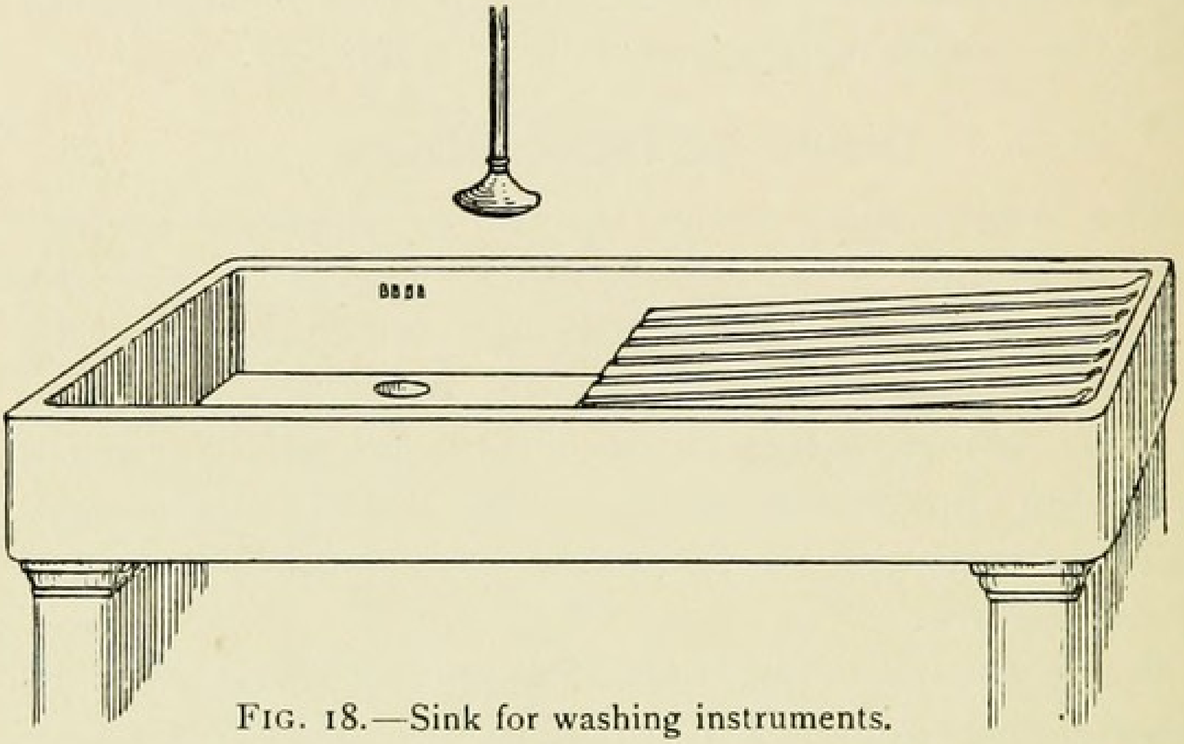


FIG. 18.—Sink for washing instruments.

Hatchway for Instrument Sterilizer.—In the wall between sterilizing and disinfection rooms, near this sink, should be a large opening or hatchway, through which the instrument sterilizer can be easily got at. This should be closed by a sliding door, so that steam is prevented from escaping into the disinfection room and theatre.

If the disinfection room is large enough, it is a reasonable thing to carry out part of the final disinfection and other preparation of the patient in it. In such a case this preparation should be done at some part of the room at a distance from the wash basins and instruments. The field of operation is scrubbed with soap and water, and dried. Bed clothing and blankets are removed, their places being taken by sterilized gown, sheets and mackintoshes. The patient

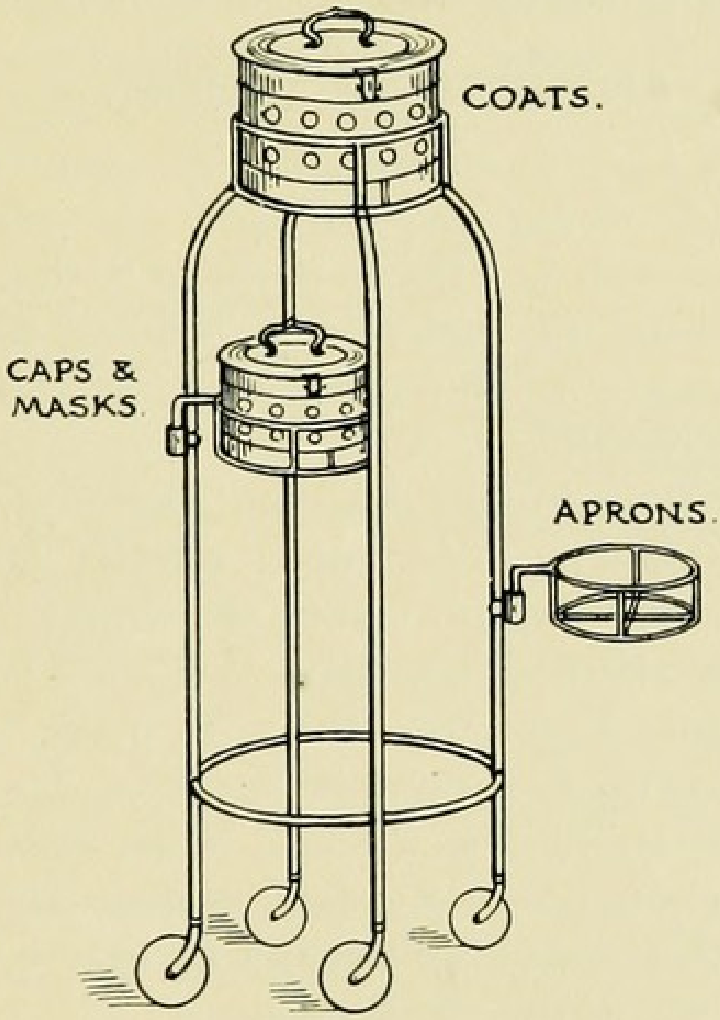


FIG. 19.—Stand for drums in disinfection room.

is transferred to the operating table. The septic clothing is taken back through the anæsthetizing room, while the patient in his sterile coverings is taken to the theatre under charge of attendants who do not carry contamination from the outer world.

Drums on Stand with Coats, Caps, Masks, &c.—There should be a stand (fig. 19) with a large drum for coats, and two smaller drums, one, divided by perforated partitions, for masks, caps and gloves, the other for linen aprons. This stand must be placed at a safe distance from the wash basins and instrument tank. There should be also an extra large drum on a separate stand containing, arranged alternately, gowns and sheets for covering the patient and operation table.

ANÆSTHETIC ROOM.

It is well to have the anæsthetizing room, or passage, closed by wide swing doors at each end (glass panels at the theatre end) so that it is unlikely that draughts gain entrance to the theatre and bear septic material from the passages. The ventilating arrangements of the theatre should be sufficient to guarantee that draught will flow in the opposite direction.

The anæsthetizing room need not be larger than will comfortably hold the trolley on which the patient lies, the anæsthetist, and perhaps two attendants, while allowing ample room for others to pass. If space permits, however, it should be large and well ventilated. There should be a small wash basin for the anæsthetist's use. A small shelf is necessary for such of the anæsthetist's paraphernalia as may be required for the early stages of anæsthesia.

Apparatus for Warming Blankets.—At one side of the anæsthetic room there should be a large exposed radiator surrounded by a strong guard, on which ward blankets removed from the patient may be warmed, pending his return from the operating theatre.

Instrument Cupboards.—On one side of the "room" the instrument cupboards may be arranged. These cupboards should be large and have well-fitting glass doors so that moisture is kept out. A separate cupboard for rubber instruments should be available. This should be in a cool place. The heat of the theatre and adjacent rooms is detrimental to rubber. The sulphur in it forms a sulphide which dulls the surface of polished steel instruments.

Having washed his hands and forearms thoroughly before beginning the anæsthesia, the anæsthetist should take the opportunity of putting on a sterile overall

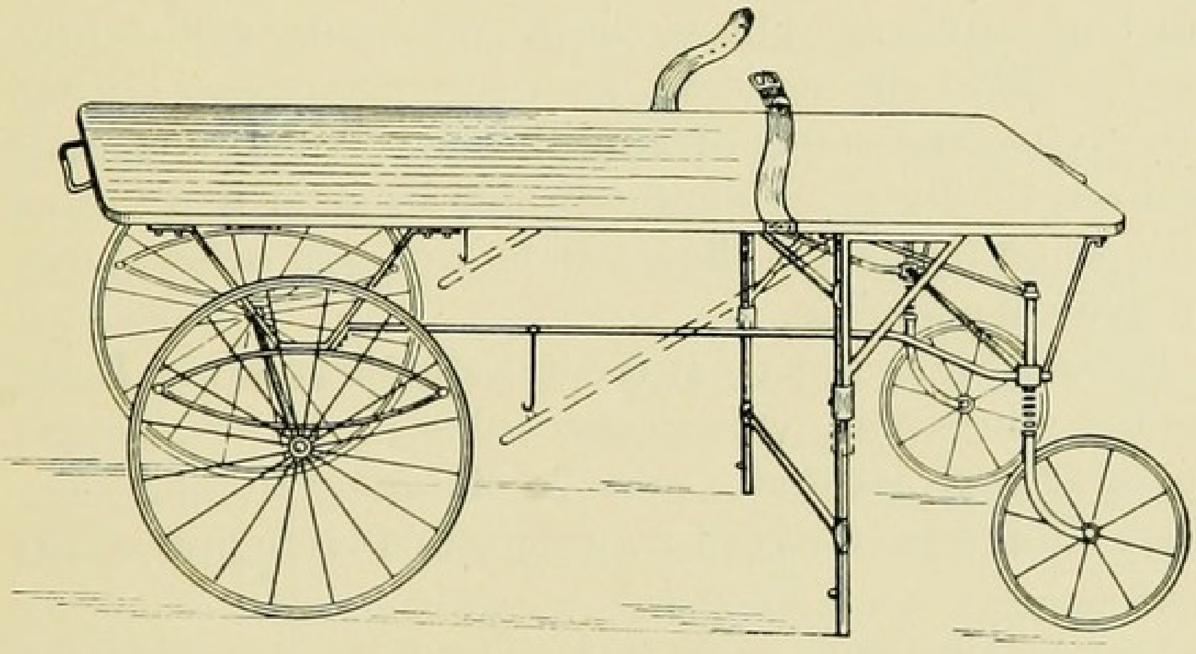


FIG. 20.—Transport trolley, showing control straps and arrangement for putting wheels out of action.

during the time the patient's skin is being scrubbed in the disinfection room. If the operation be made on the head, the anæsthetist should wear sterile gloves as well.

Transport Trolley.—The trolley for transport of the patient should be strong, light, 6 ft. 6 in. in length, 2 ft. broad, with firm springs, and of the same height as the operation table. The wheels should be at least a foot in diameter, with ball bearings. It is of no great consequence whether the trolley be made of wood or metal. To save polishing, it should be painted with white enamel. It should be hosed over daily as a routine procedure. As the trolley is often used for small operations, it should have an arrangement for putting the wheels out of action (fig. 20).

Control Straps.—Hung over a hook on the wall should be a supply of broad straps or pieces of webbing with easily working large buckles, or other efficient catches. These straps are made sufficiently long to bind the patient's knees to the trolley during the excitement stage of anæsthesia. The straps may be fixed to the sides of the trolley in such a position that, when tightened, they will lie an inch or so above the patient's patellæ.

Hanging Wardrobe.—If the anæsthetic room be large enough, the coats, waistcoats, collars and ties, of the operator and assistants may be hung up at one side. They should be covered by a curtain ("hanging wardrobe").

Seat for Patients.—A seat should be provided for patients who can walk from the wards. In spite of all care, they have sometimes to wait for a considerable time before their turn comes.

Stomach Tube and Tracheotomy Instruments.—A stomach tube and set of tracheotomy instruments should be in readiness in a small cupboard in the anæsthetizing room. These should never be removed from the operating department, otherwise when required in emergency they are sure to be elsewhere.

STERILIZING ROOM.

The sterilising room for the individual theatres need not be large (6 ft. by 8 ft.), if lofty. The walls, floor, and roof should be made of glazed tiles or some material which will stand extremes of temperature well.

Special Ventilation.—There should be in or near the roof some arrangement whereby vapours are strongly sucked out of the room, so that the vapours will not escape to the theatre or annexa when communications are opened.

Instrument Sterilizer.—A slate slab, firmly supported by iron or bronze brackets, and large enough to give ample room for the instrument sterilizer, should fit partly into the opening in the wall previously mentioned in the description of the disinfection room. A large size of sterilizer, at least 19 in. by 10 in., should be provided. It should be of copper, or nickel plated, and should be heated by steam coils arranged along the bottom and sides. Two or three trays for instruments should be provided—the sterilizer being made deep enough to hold all three trays at once if necessary. A modern form of sterilizer has a water-jacket above the level of the water in the sterilizer, in which a stream of cold water is kept circulating. This condenses the steam which ordinarily puffs out in a great cloud when the lid of the sterilizer is raised. This arrangement is unnecessary when the ventilation of the sterilizing room is working efficiently, because then all the steam is drawn into that room. The lid of the sterilizer should open by a lever arrangement towards the interior of the sterilizing room, so that it is not in the way of the person in the disinfection room who may be manipulating the trays. In fact, an arrangement may be made whereby the lid of the the sterilizer and the hatchway are opened and shut simultaneously.

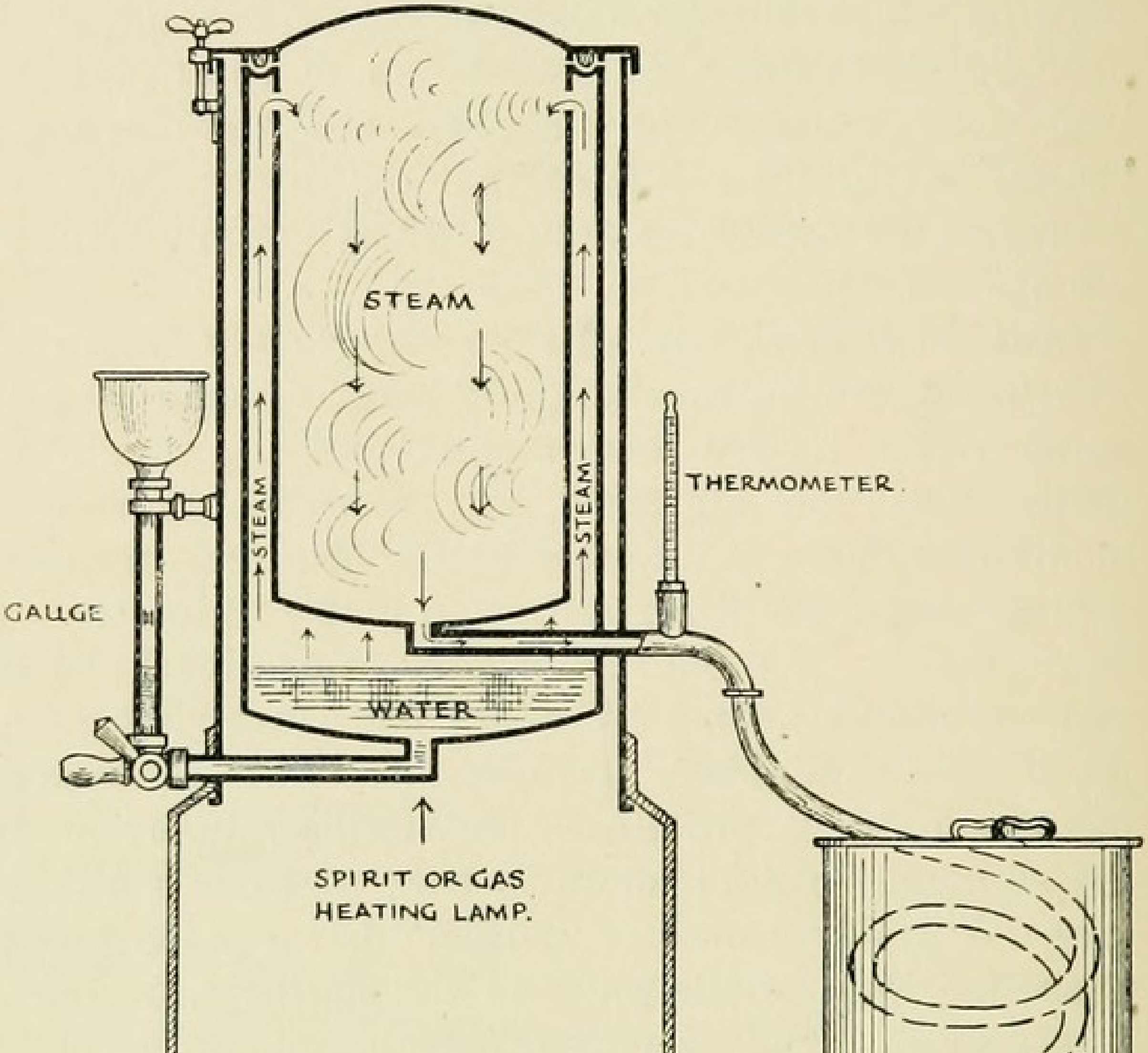


FIG. 21.—Scheme of ordinary steam sterilizer for coats, towels, dressings, &c.

High-pressure Sterilizer.—A high-pressure steam sterilizer for coats, towels, dressings, &c., stands on the floor. Any of the well-known instrument-makers can furnish a satisfactory pattern. In small cottage hospitals and for private use the ordinary "Lautenschläger" pattern, to hold at least 2 drums, 10 in. by 13 in. is quite efficient. Care must be taken not to pack the contents of the drum tightly in case the steam does not penetrate (fig. 21).

Tanks for Sterile Water.—Two 50 to 100-gallon tanks for hot and cold sterile water are placed on a shelf at least 8 feet from the floor. These tanks are heated by coils of pipes which are connected with the steam apparatus of the hospital. The steam for heating the theatres and sterilizers should be carried in a circuit of pipes which has no connection with that of the rest of the hospital, so that in summer the one may be used without the other. The tanks are filled from the ordinary water supply. The supply pipe is welded into the side of the tank near the top, and provided with a strong thoroughly efficient stopcock. The tanks should have gauges to show how much water they contain. They should be ventilated at the top by a pipe which curls over the side of the tank and opens downwards; the opening being closed with wire gauze and cotton-wool in order to filter the air. In the interior of each tank there should be a coil of pipes connected with the cold water circulation, so that, after being sterilized the water may be rapidly cooled when desired. The lid of the tank should be screwed on, so that it can be removed for periodic inspection and cleaning of the interior. It should be especially observed that no leakage is present in the cold water coils.

Tank for Saline Solution.—In some establishments another smaller tank is provided for saline solution, but this is unnecessary.

Sterilizer for Basins, Jugs, &c.—A sterilizer for basins, jugs, irrigators, &c., stands on the floor. It may be round, as in fig. 22, or oblong. It is heated by steam

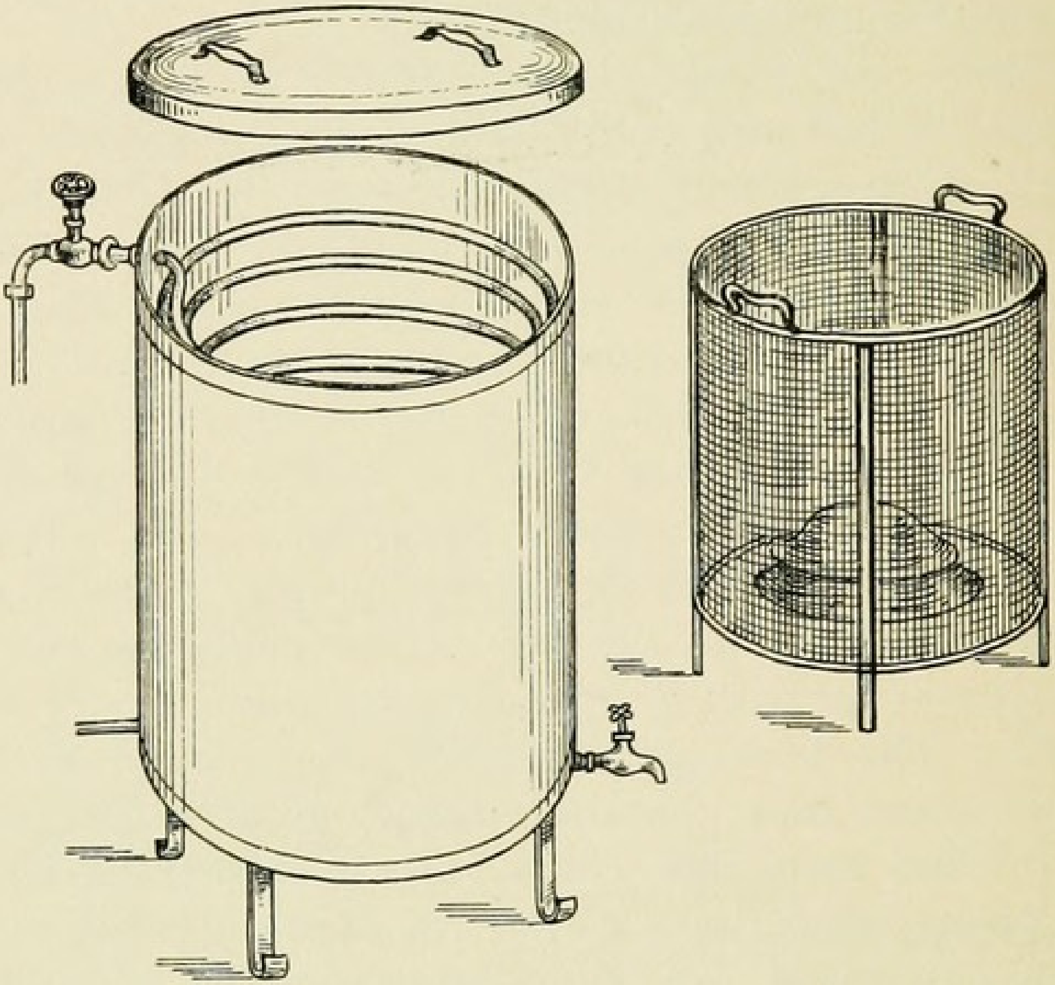


FIG. 22.—Sterilizer for basins, jugs, &c.

coils. Into it fits a removable strong wire cage (provided with legs 3 in. high) with large meshes, into which the articles are placed. The size of this sterilizer and cage will vary with the size and quantity of articles to be sterilized. There should be several such cages available, so that separate basins, &c., for each operation may then be sterilized. On removal from the sterilizer, the cage should be covered by a sterilized towel.

These articles may, of course, be sterilized in the high-pressure apparatus, but it is more convenient to have a separate "boiler" when basins and so forth have to be sterilized during operations.

PREPARATION AND STERILIZATION OF LINEN MATERIALS, DRESSINGS, Etc.

Drums for Coats, Towels, Dressings.—It may be well to describe here the kettles or drums for holding

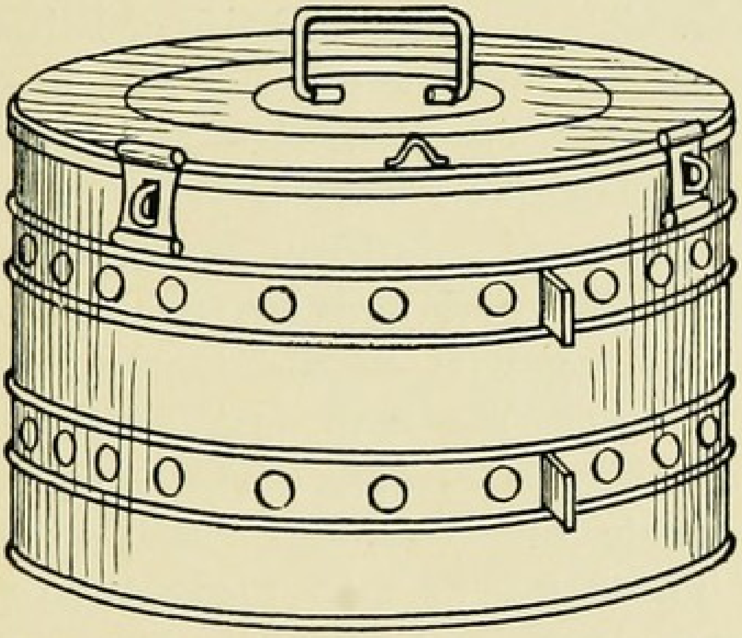


FIG. 23.—Drum or kettle for sterilization of towels, dressings, &c.

coats, towels, dressings, &c., for sterilization. They are usually made of plated metal, in various shapes and sizes. In the larger ones are placed the more bulky articles; in the smaller, such articles as dressings, bandages, gloves &c. The simplest form is that of a circular box, whose lid has overhanging edges and can be clamped down. In the sides of the box are numerous perforations, which can be closed by a sliding band (fig. 23). A lining of linen or fourfold gauze should be made to fit the interior accurately, and inside this the articles to be sterilized should be loosely laid. The lining prevents protrusion of these articles through the perforations and helps to prevent the penetration of dust during transport. The lid is clamped down, the perforations are opened, the drum is placed in the sterilizer, the lid of which is fixed down, the steam screwed on (high-pressure sterilizer), or the water *boiled* (Lautenschläger), for at least twenty to thirty minutes. At the end of this time the kettles are removed and the perforations closed. They are now ready for use. The number and size of kettles or drums required depends upon the practice of the surgeon.

Aseptic Coverings for Patients.—It is desirable that the gown and blankets covering the patient during transit from the ward should be discarded at the door of the disinfection room, and be replaced by sterilized coverings. The gowns should be made of woollen material, cut large, made to fasten down the back, and have short, wide sleeves. The blankets (6 ft. by 4 ft.) are made of thick flannelette or some such material. These gowns and blankets are kept in a specially large drum in the disinfection room.

Operation Sheets and Towels.—Sheets (6 ft. by 6 ft.), towels (4 ft. by 2½ ft.) are made of huckaback material. Some prefer smooth linen. A large sheet with an oval opening in the middle, through which the site of the incision was exposed, was at one time in favour. Nowadays the sheets and towels are so clamped to the skin of the patient (see p. 301), that an opening is left, varying in size and shape with the extent and direction of the wound.

The sterilized sheets and towels are kept, arranged in series, in one of the large drums on the theatre frame (fig. 11).

Swabs.—In the other large drum on the frame are swabs. These may be: (*a*) small quantities of plain absorbent cotton-wool, teased lightly and sewn or tied into gauze. (*b*) Cut gauze squares. (*c*) Specially prepared washable gauze squares.

The first form is most useful, but, unless great care is taken, they are liable to be left in the depth of the wound into which they have been placed. The gauze squares must be large, otherwise the same objection holds good. In any case it is necessary to attach tapes or clamps (artery forceps) to any swabs placed in a deep wound. For abdominal work many surgeons use specially long, broad, fourfold, folded gauze strips, or large pads made in the same way as the wool swabs, in order to prevent dissemination of deleterious matter throughout the abdomen; these are provided with tapes, which are clamped together with a forceps outside the abdomen.

The objection to the cut gauze squares is that little tags of thread become detached from the cut margin and are frequently left in the wound. If these are infected they may be the cause of prolonged suppuration. The specially prepared squares have not this disadvantage, and being washable, are on the whole cheaper. They are supplied by various firms.

Dressings.—For general purposes plain sterilized gauze is most useful, cut in pieces 6 in. square. This is stored in one division of a small drum, the gauze strips mentioned above being in the other division. A few folds of gauze are placed next the wound, and are covered with a thick mass of cotton-wool.

Gauze impregnated with antiseptics is more expensive, and of doubtful value. It causes irritation in a wound, which, of course, may do good by provoking an increased flow of discharge, but any beneficial action may be destroyed by the action of the antiseptic. Irritation of the skin ought to be avoided. If increased flow of serum is required in a wound, this is better procured by Bier's congestion or Klapp's suction glasses, or by stimulating osmosis as Sir A. E. Wright has suggested.

In order to stimulate more rapid loosening of gauze strips when packed in a wound, they may be wrung out of dilute solution of hydrogen peroxide before being inserted.

Plain absorbent cotton-wool is the best external dressing, unless there is fear of septic infection from neighbouring parts, such as the anus or urethra. In such cases salicylic or alembroth wool may be used, or the wound and surrounding skin be dusted with a non-irritating antiseptic powder, before the plain dressing is applied. The drum for the wool is indicated on fig. 11.

Bandages and Binders

The variety of these is legion. Each practitioner will no doubt be guided in his selection by the practice of the school in which he was trained. Bandages and binders, suitable for the day's operations, may be sterilized in a separate small drum and kept on the large table at the side of the theatre.

Adhesive Plaster.—In cases where there is much tension on a wound, or where the patient is likely to be restless, it is advisable to take off the strain or fix the dressing by strips of adhesive plaster. The most suitable hitherto produced is "Beiersdorf's Leukoplast." For abdominal wounds the plaster should extend from within a few inches of the spine on one side, round the front of the abdomen over the wound, to within a few inches of the spine on the other side. Some surgeons make routine use of this in abdominal cases. The frequent tendency of the plaster to fall into folds may be prevented by putting on a second layer, at the same time interposing short strips of veneer or perforated zinc (1 in. wide) between the two layers.

STERILIZATION OF INSTRUMENTS.

Non-cutting instruments should be boiled in water for ten to fifteen minutes. Cutting instruments should have grease removed with methylated spirit or ether, and be boiled for two to three minutes only, otherwise the edges may be dulled.

A sterile sheet is spread on the instrument table, and after sterilization the instruments are tipped or lifted with a forceps from the tray on to the sheet, suitably arranged, and covered with a sterile towel. In theatres where many onlookers are present, it is probably safer to have special instrument trays (white enamelled metal), in which the instruments can be immersed in a weak non-corrosive antiseptic solution.

One basin at the side of the instrument table contains lotion (saline lotion), and swabs for cleaning instruments during the operation; the other contains lotion and nail-brush for cleansing the hands of the person in charge of the instruments. Both these lotion basins must be frequently changed.

At the end of an operation the instruments are taken to the disinfection room, washed at the instrument tank, placed on a tray and sterilized, after which they are either used again or dried, polished, and stored in the instrument cupboard.

CHAPTER III.

LIGATURES AND SUTURES.

Absorbable.

In all cases buried ligatures or sutures should be, if possible, absorbable. In cases where large vessels, thick pedicles, or elastic yielding tissues are tied, the ligature is preferably of silk, which is less likely to be dislodged, or the knot on it to slip, than in the case of catgut.

Catgut.—The absorbable ligature or suture *par excellence* is of catgut. It has the disadvantage of being difficult to sterilize without causing it to lose its pliability and tensile strength. The difficulty is indicated by the numerous methods of preparation.

Great care must be exercised in its sterilization because it is manufactured from strips of submucous tissue from the intestine of sheep. It is evident that infection can be transmitted to a wound through carelessness in the preparation.

Catgut can be bought from all instrument makers either in the raw or prepared state. It is advisable that the operator himself should conduct, or be responsible for, the final stages of sterilization. Although very great care may be bestowed on its preparation by wholesale houses, yet one is not justified in using their material and then blaming manufacturers for wound infection when oneself should bear it. The most certain method of sterilization is by boiling.

Unless this is carried out in a particular way, the catgut is rendered brittle and useless, or else too unabsorbable. For ordinary purposes catgut need not remain longer in the tissues than ten days. For special purposes catgut is prepared by, for example, the "chromic" method, so that it will remain unabsorbed in the tissues for two, three, four weeks, or even longer.

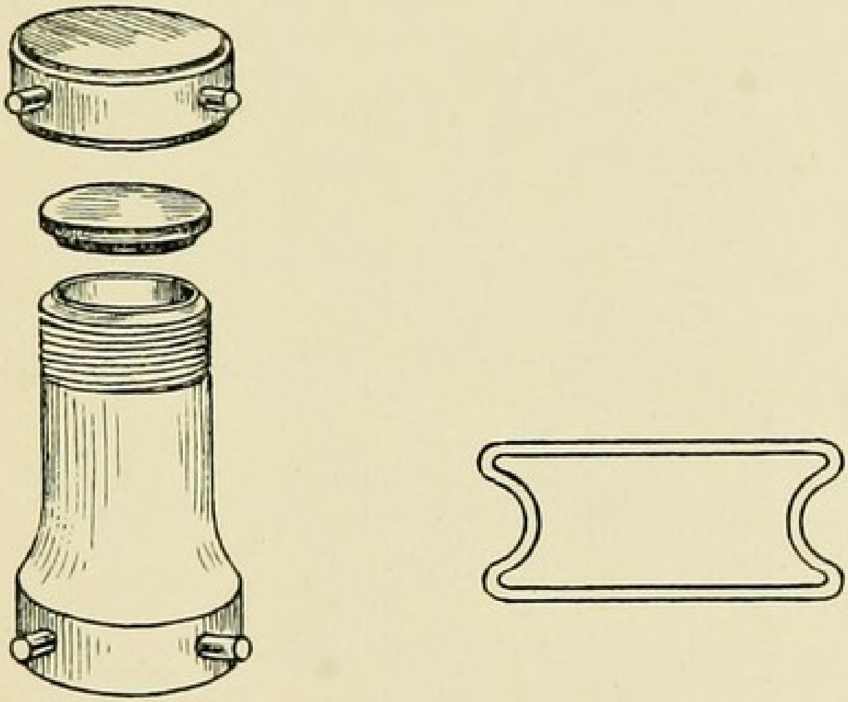


FIG. 24.—Mayo Robson catgut sterilizer with steel or glass spool on which the catgut is wound.

Catgut is sold in varying thicknesses or strengths, numbered from 000000, 00000—1, 2—8. Of these Nos. 1 and 2, preferably No. 1, are most useful for general purposes.

The writer buys No. 1 prepared formalin catgut in small hanks containing 10 to 12 ft. This is wound lightly on steel spools and boiled in Mayo Robson's catgut sterilizer for at least twenty to thirty minutes (fig. 24). The sterilizer is filled, half to three-quarters, with methylated spirit. This method is simple and efficacious; the catgut is strong and pliable. Care must be taken, however, that no water gains access to the catgut, otherwise it swells up and becomes brittle. The sterilizer holds three such spools comfortably, and it will be found that this quantity of catgut is ample for any operation. A number of such sterilized spools may be stored, either dry or immersed in methylated

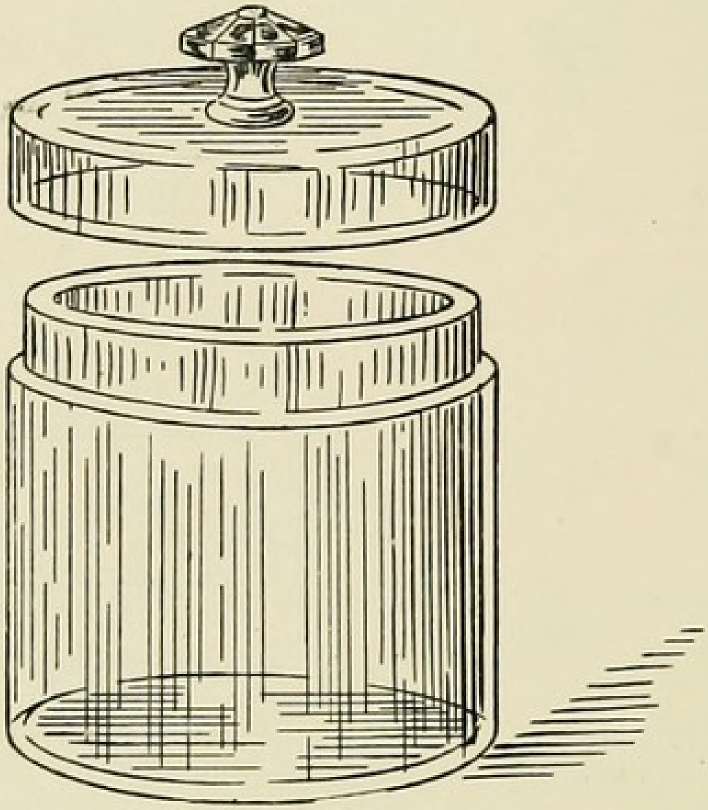


FIG. 25.—Glass jar for ligature or suture material.

spirit, in a sterilized wide-mouthed glass jar with overlapping glass top (fig. 25). At operation the catgut spools may be placed with the other instruments on the dry sterile sheet, or immersed in methylated spirit in a small shallow trough.

Catgut Sutures.—To avoid handling the sterilized catgut, the writer uses the following method. Before sterilization, the needles are threaded, and fixed as in fig. 26, in a strip of lint. The long free end of each suture is knotted in the lint to prevent warping of the catgut during boiling. The lint is then wound tightly on a wooden cylinder 1 in. in diameter and the whole is boiled in methylated spirit in a specially large

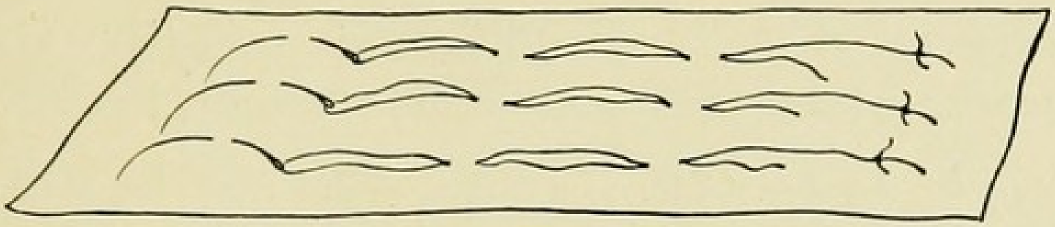


FIG. 26.—Catgut sutures fixed in strip of lint, preparatory to sterilization.

steriliser, similar to the small one introduced by Mayo Robson. In use, the lint is tacked at each end to the wooden cross-pieces of the sterilized metal frame shown in fig. 27, which lies on the sterile sheet for

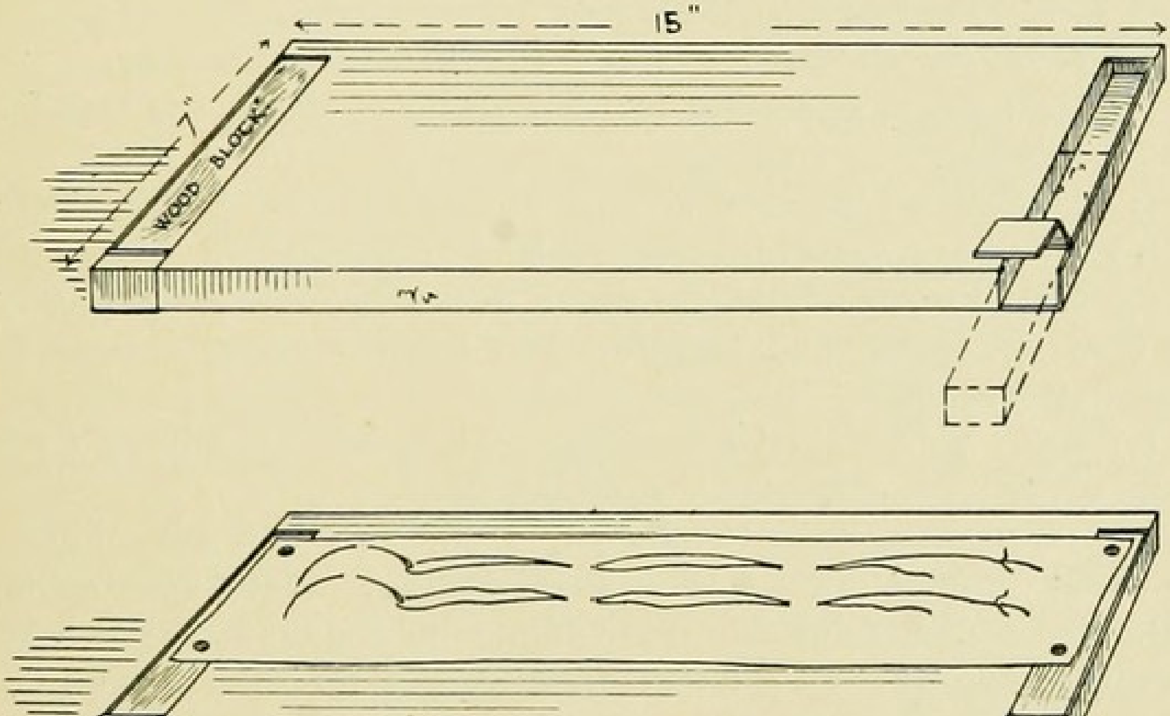


FIG. 27.—Metal frame and wooden cross-pieces on which to fix the strip of lint carrying sterile catgut sutures. The wooden pieces are easily replaceable when destroyed by repeated boiling.

instruments or immersed in spirit in a special tray. The sutures are easily removed from the frame by snipping the fixed end and drawing out the needle end with a forceps. If the dry method be not used, it is obvious that another small table is required to hold the trays for ligatures and sutures.

Common Methods of Preparing Catgut. — Other methods of preparing catgut, in common use, are :—

(*a*) *Iodine Method.*—The raw catgut, as got from the maker, is wound, in single layer, on glass spools or slabs and placed directly in the following solution : iodine, 1 part, methylated spirit, 15 parts; and left for eight days, when it is ready for use.

A solution recommended by Claudius was : 1 per cent. iodine and 1 per cent. potassium iodide in watery solution. Raw catgut, freed from fat, is immersed in this for 8-10 days, and may be used directly out of the solution, the excess of iodine being washed off by rinsing in methylated spirit, or it may be used dry by being kept in Petri dishes (Moschcowitz).

(*b*) *Bartlett's Method.*—(1) Dry catgut in hot-air chamber.

(2) Heat slowly and never above 220° F., at which it is kept for thirty minutes.

(3) Transfer wtth sterile forceps to asbestos-lined kettle, where it is allowed to remain in liquid albolene for twenty-four hours.

(4) Heat in a sand-bath in which the temperature is gradually elevated to 320° F. and maintained at this point from one-and-a-half to two hours.

(5) Keep in sterilized condition in glass jars containing 1 per cent. crystal iodine in best Columbian spirit.

(*c*) *Ammonium Sulphate Method.*—Wind catgut firmly on glass or metal cylinders. Place in an enamelled pot containing a boiling saturated watery solution of pure ammonium sulphate, and boil for twenty minutes. The solution must have a lead-like film on the surface; this indicates super-saturation. Then with sterile dressing forceps transfer to sterile water and rinse backwards and forwards several times to free the threads from adherent small particles. Place in 96 per cent. alcohol for about twelve hours, and store in juniper oil.

(*d*) *Chromic Method.*—(1) Soak ordinary raw catgut in ether.

(2) Place in 4 per cent. aqueous solution of chromic acid for twenty-four hours.

(3) Steep for twelve hours in sulphurous acid solution. By varying the time the catgut is left in chromic acid, the length of time for absorption in the tissues can be varied. It can be prepared so that it does not become absorbed for three or four weeks.

Kangaroo Tendon.—Kangaroo tendon is held in great favour by some surgeons for suturing the inguinal and femoral canals in hernia operations, but is really unnecessary. It can be obtained sterilized in tubes from any instrument maker.

NON-ABSORBABLE LIGATURES AND SUTURES.

Silk.—Chinese twist, floss silk or plaited silk are used, according to choice of different surgeons. The smaller sizes, 00 to 1, are used for delicate suture or ligature work where strength and durability are required, as, for example, bowel suture, side ligature of veins, suture of arteries, &c. The coarser forms are used for ligature of thick pedicles or large vessels, for interrupted deep suture of abdominal wall, &c.

Pagenstecher's Thread.—Silk is unsuitable for suture of the skin owing to its capillary action and permeability to septicity. Surgeons are using, more and more frequently, thread (linen) impregnated with celloidin, or similar material, in order to overcome the objection urged against silk. So-called Pagenstecher's thread is an example of this in common use.

Silkworm Gut. Horsehair.—From this point of view silkworm gut, sold in different sizes, or horsehair, are the two best sutures for the skin.

Whatever kind of non-absorbable suture be used, it may be wound on glass or metal spools, wrapped in a napkin, and sterilized with the dressings. The silk-worm gut or horsehair is usually boiled with the instruments.

Sutures may be threaded beforehand, rolled as in figs. 28 and 29, the needles fixed in lint, and the whole sterilized with the dressings.

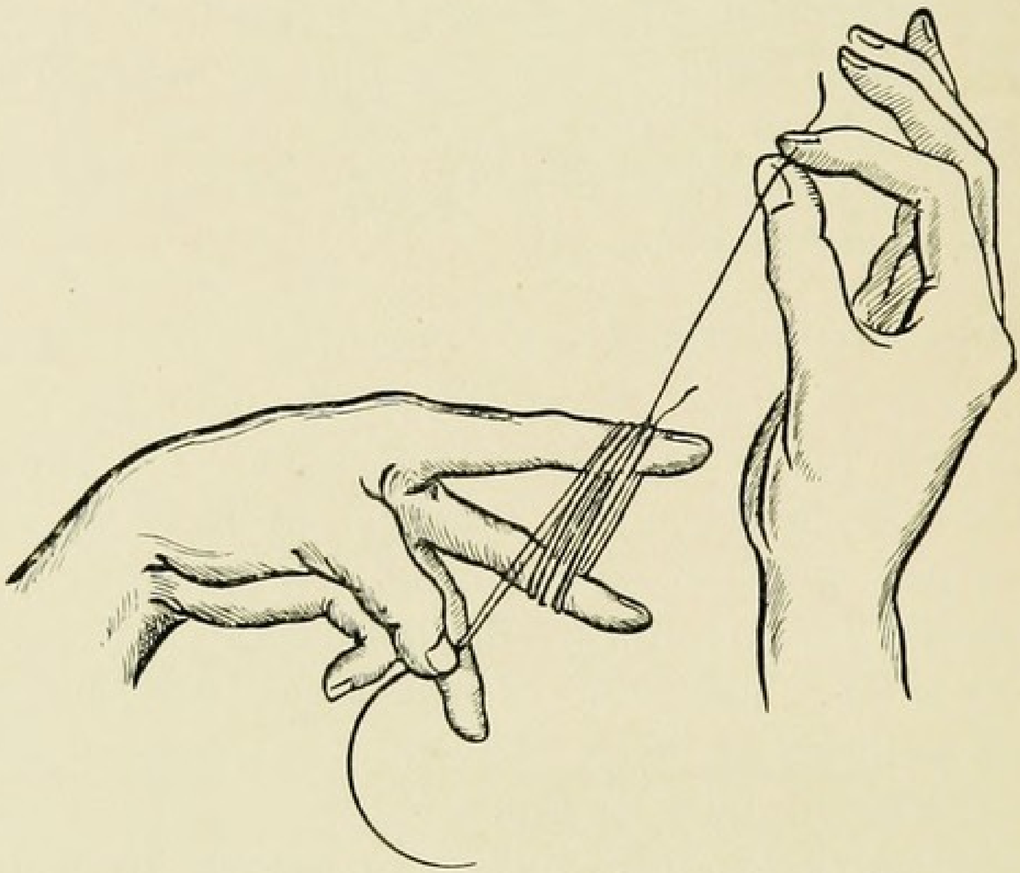
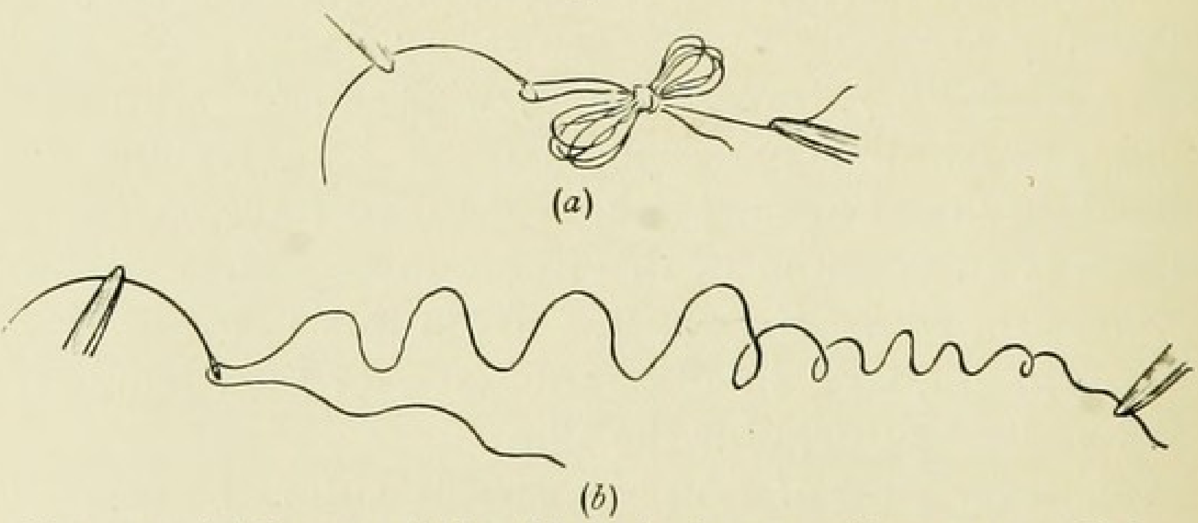


FIG. 28.—Method of winding silk suture before sterilization.



(*a*)

(*b*)

FIG. 29.—(*a*) Suture rolled and held by forceps; (*b*) suture unrolled and ready for use.

NEEDLES.

The size, shape, and kinds of needles used by different surgeons are very varied. This indicates that the choice of needle is not of very great importance. The operator will use that which, from experience, he finds to be most convenient.

For the skin and certain dense tissues, needles with cutting edges must be used; for other parts, rounded needles are indicated. These needles are made straight, half curved, and fully curved. A "Paterson" eye tends to prevent the suture slipping out of the needle. Intestinal needles are fine, round-bodied, straight or curved.

On the whole, the writer finds that fully curved needles are preferable, but opinions on this matter

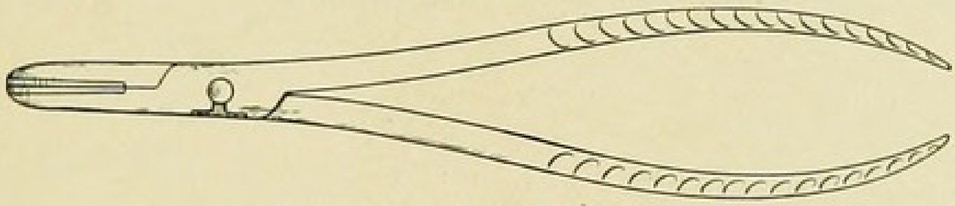


FIG. 30.--Needle holder.

vary so widely that it is inadvisable to go into it more fully.

Handled Needles.—Two to four strong handled needles, of different curves, should form part of the instrumentarium of every practitioner.

Needle Holder.—A needle holder should be used whenever possible. An efficient and simple form, not likely to get out of order, is that depicted in fig. 30. The use of a needle holder prevents possible contamination from fingers.

Special apparatus, like Michel's clips, for closure of wounds, are refinements which are unnecessary in general practice.

Sutures.

Of Deep Tissues.—When the tissues in the depth of a wound are uninfected, they should be brought together as nearly as possible in their natural position, by means of, preferably, absorbable sutures. These sutures may be interrupted or continuous. The remark applies potently to suture of the linea alba or the sheaths of muscle. The elastic fibres of the linea alba are found experimentally not to grow across the scar if the separation of the edges is greater than 2 mm. These fibres are indispensable for a sound scar.

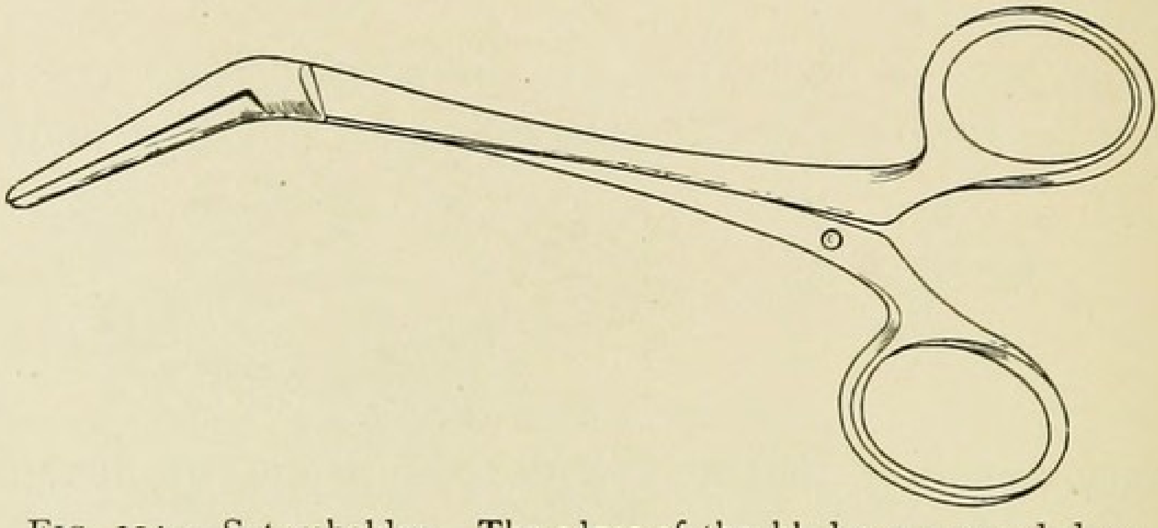
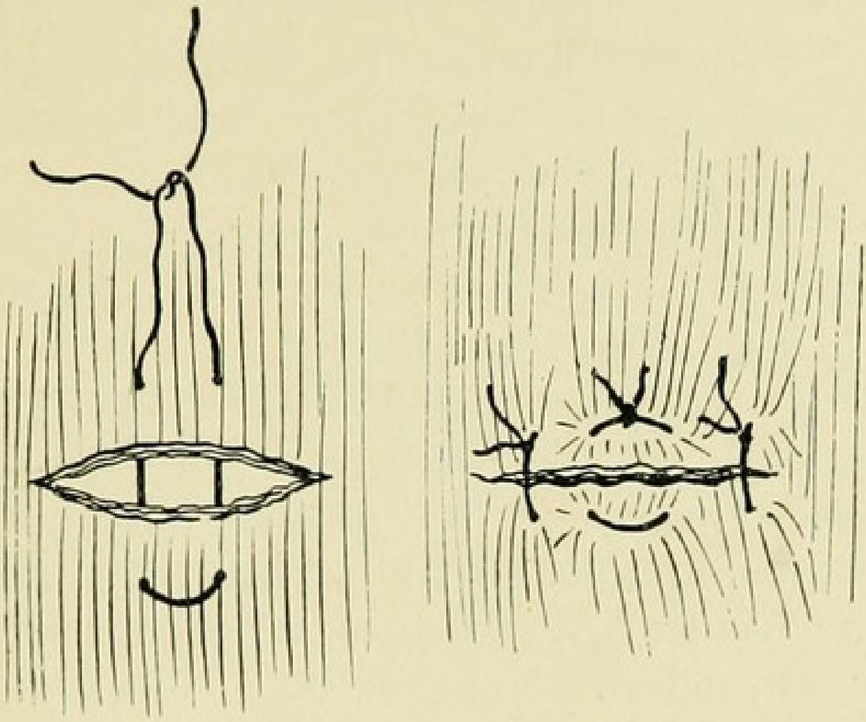


Fig. 30a.—Sutureholder. The edges of the blades are rounded so as not to cut or fray the suture.

Sutures should not be drawn so tightly as to strangle any parts, but merely enough to make these parts lie snugly. In certain cases, *e.g.*, in the aponeurosis of the abdominal wall, tension may be so great that strong and unabsorbable material (silk) has to be used. In such cases infection of the suture must be specially guarded against, because the tension of itself causes a limited necrosis. If the ordinary suture fails to hold, a properly introduced mattress suture will



(*a*) (*b*)

FIG. 31.—Mattress suture—(*a*) inserted ; (*b*) tied.

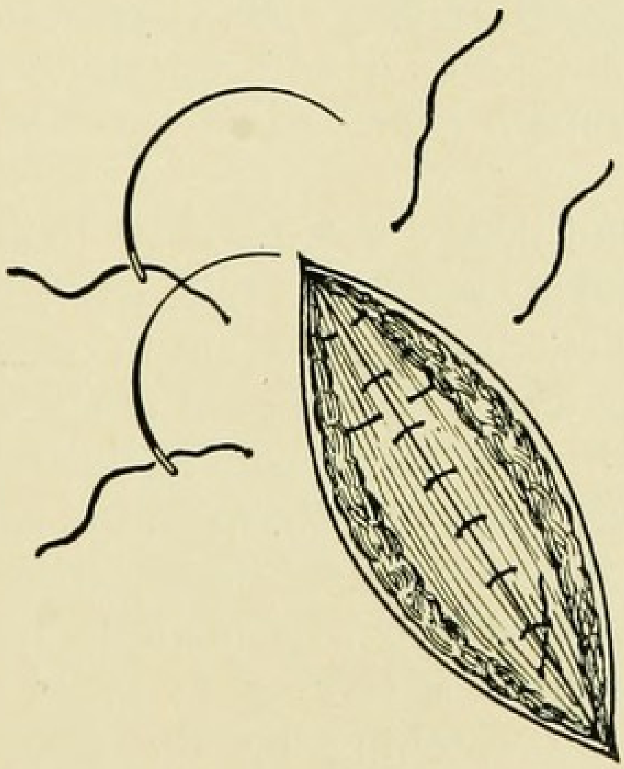


FIG. 31 A.—Showing skin suture catching up deep fascia.

suffice (fig. 31). In inserting sutures care must be taken to avoid including or wounding important nerves or vessels. In tying either ligatures or sutures, reef or surgical knots should be used to prevent slipping. The free ends should be cut not longer than $\frac{1}{4}$ in.; as little foreign material as possible should be left in the depth of a wound.

Suture of special structures, such as tendons or nerves, is dealt with in the articles on these subjects.

Of Skin.—The perfect suture material for the skin possesses smoothness, strength, elasticity, and at the same time has such a structure as to have little or no capillary attraction. None of the ordinary materials possesses all these qualifications. Horsehair approaches perfection most nearly, but lacks strength. Silkworm gut is possibly used as widely as any. Silk and ordinary threads have strong capillary attraction, but the latter, when impregnated with celloidin or similar substance, is a thoroughly useful material.

The important points in suturing skin wounds are :—

(1) Approximate the edges of the epithelium accurately.

(2) Insert and tie the stitches so as to avoid strangulation of the skin, otherwise necrosis, stitch suppuration, and ugly stitch marks are apt to occur.

In situations where there is not much subcutaneous fat, if the skin has been cut vertically, the needle should be inserted about $\frac{1}{3}$ in. from the edge, vertically or even in a direction slightly away from the wound; should pass fairly deeply; be made to traverse across the wound in such a way as to avoid leaving dead spaces (even by catching up the fascia or muscle sheath in the depth, fig. 31A), and then to emerge through the opposite side in a way similar to its introduction. In this way it will be found that the edges of the epithelium will tend to lie accurately together

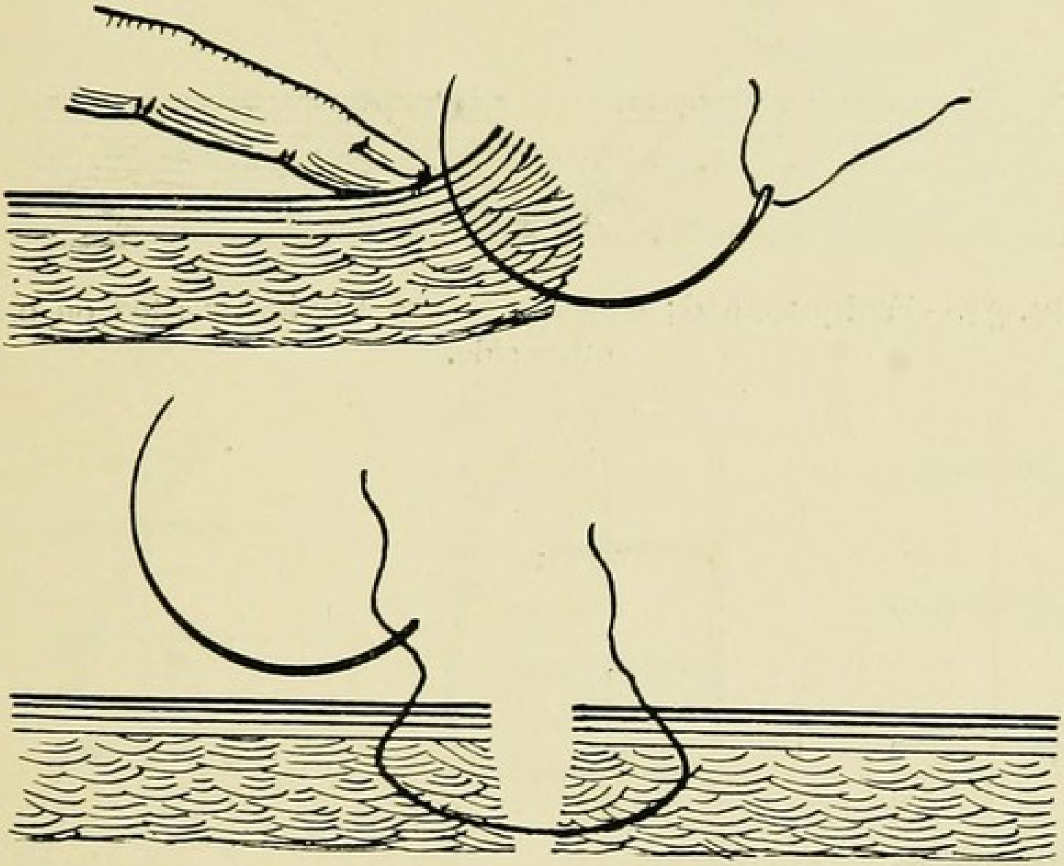


FIG. 32.—Method of inserting skin suture.

(fig. 32). If the needles be inserted as in fig. 33, the edges are more apt to become inverted on one or other side.

If there be much subcutaneous fat, some insert the sutures so deeply as to reach the underlying muscle sheath, but a nicer-looking and better scar may be obtained by inserting a buried continuous suture in the fat and uniting the skin as just described. The deeper the hold which the suture is made to take, the further away from the edge of the wound must the needle be inserted through the skin.

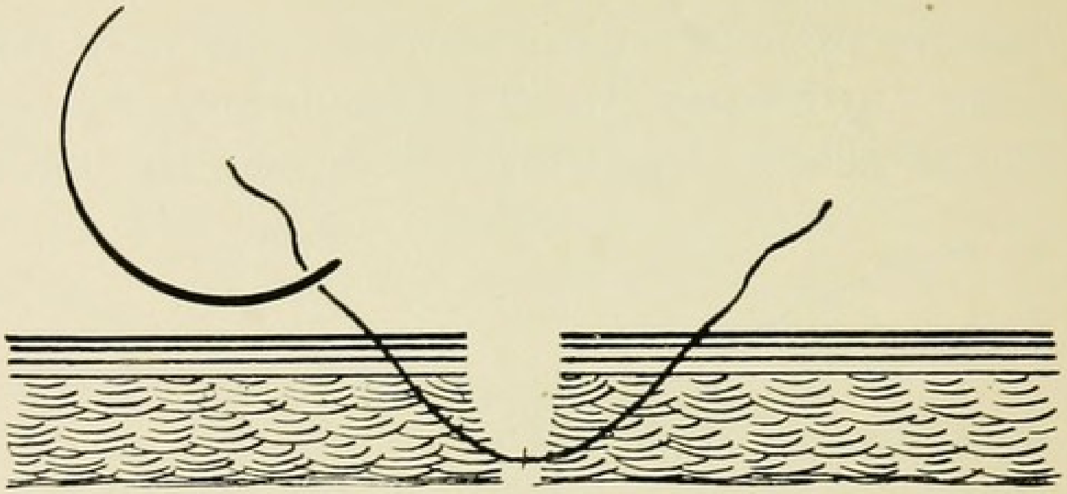
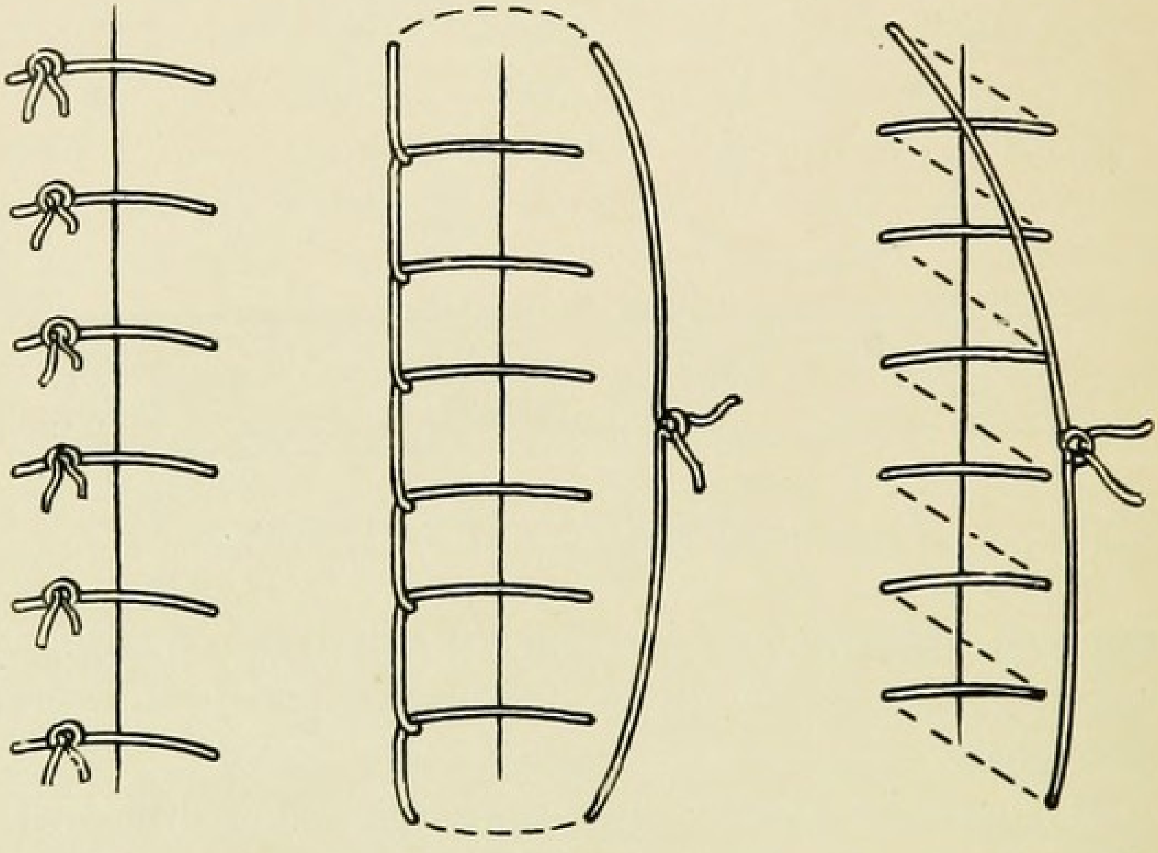


FIG. 33.—Faulty method; edges of skin apt to be inverted on one or other side.



(*a*) (*b*) (*c*)

FIG. 34.—(*a*) Interrupted suture; (*b*) looped, and (*c*) ordinary continuous sutures.

The various forms of skin suture are depicted in fig. 34.

For ordinary aseptic wounds one or other of the continuous methods suffices. If there be unequal tension on the skin, or the possibility of sepsis in the wound, *e.g.*, in secondary suture after abscess, interrupted sutures are advisable.

Where a through-and-through suture is used, for example, in the abdominal wall, or for closure of fistula, the suture may be prevented from cutting out by the simple expedient shown in fig. 35, where the thread is pulled through a short piece of narrow drainage tube ($\frac{1}{4}$ in. thick).

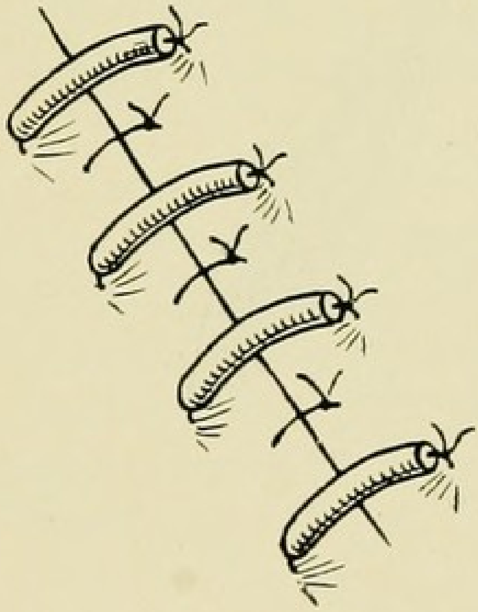


FIG. 35.—Interrupted suture, protected by tubing to prevent cutting out.

Subcuticular Suture.—Where infection from the urinary or fæcal discharges is to be feared, or in parts of the body where, for cosmetic reasons, a neat scar is required, the subcuticular suture should be used. In operations about the lower part of the abdomen and upper part of the thighs, this is very desirable in order to avoid infection through the multiple needle punctures made by ordinary suturing. Subcuticular suture is made with strong silkworm gut or fine wire. The suture does not require tying (fig. 36).

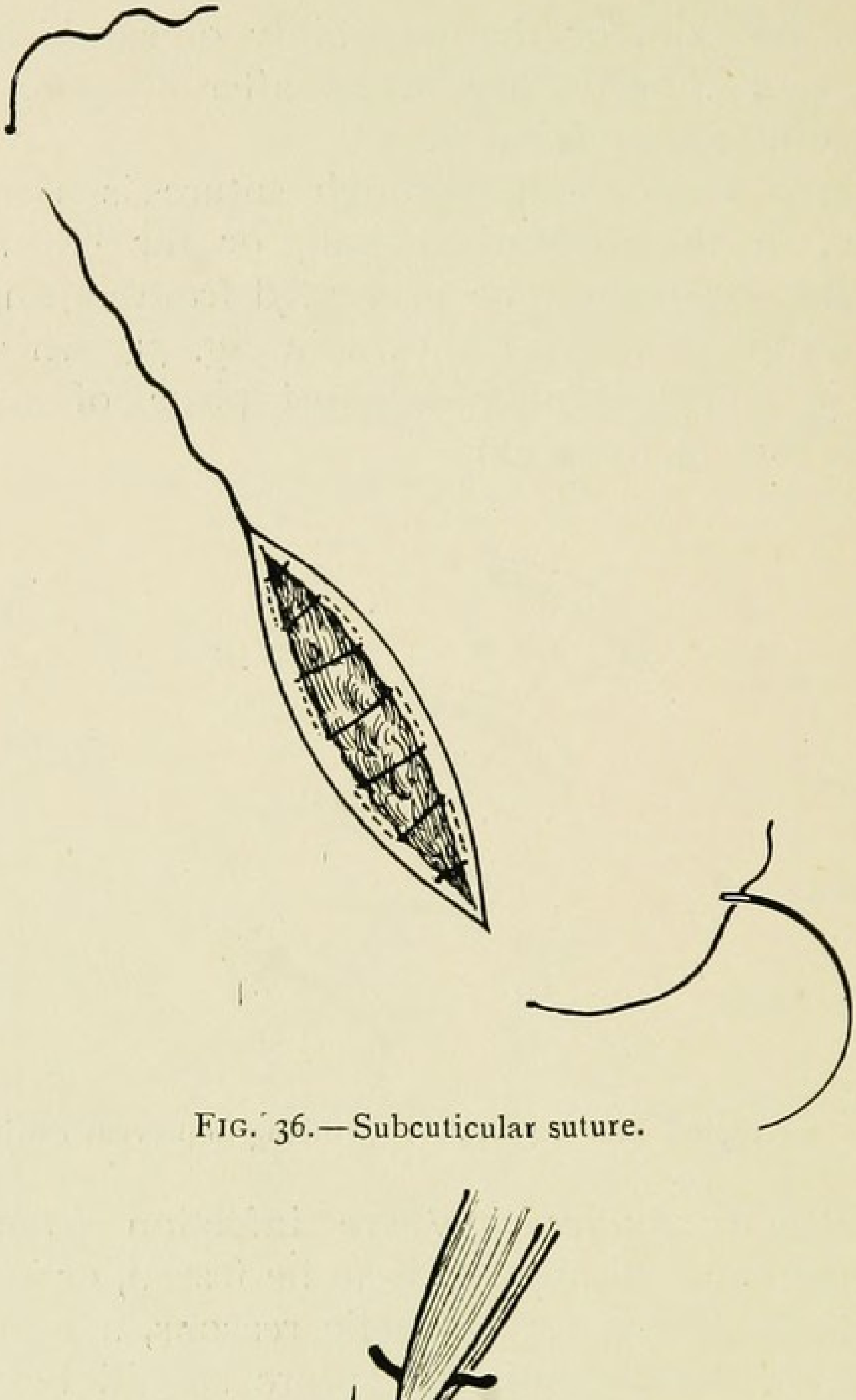


FIG. 36.—Subcuticular suture.

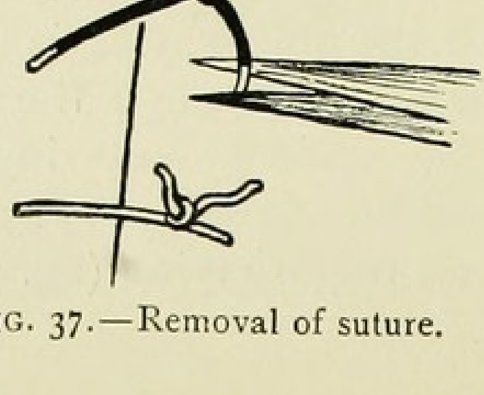


FIG. 37.—Removal of suture.

Removal of Sutures.—Interrupted and continuous sutures are removed as in fig. 37. The suture should be pulled out a little way from the puncture on one side, and cut with sterile scissors at the part which was buried under the skin, in order not to carry infection through the suture track, by pulling part of the previously exposed thread along it.

Subcuticular suture is removed by fixing one end, pushing the skin along the suture, cutting short the end thus exposed, and then pulling firmly on the other end in the line of the wound and parallel to the skin. The wound is meanwhile supported by a sterile swab.

From aseptic wounds, the suture may be removed on the third to the fourteenth day, according to the amount of tension on the wound. If a suture is causing irritation it should be removed at once. The edges of the wound are then kept in approximation by means of adhesive plaster.

CHAPTER IV.

WOUND DRAINAGE.

Where there has been infection in the depth of a wound, or where accurate apposition of the deep parts is impossible, or where compression cannot be suitably applied, drainage is necessary.

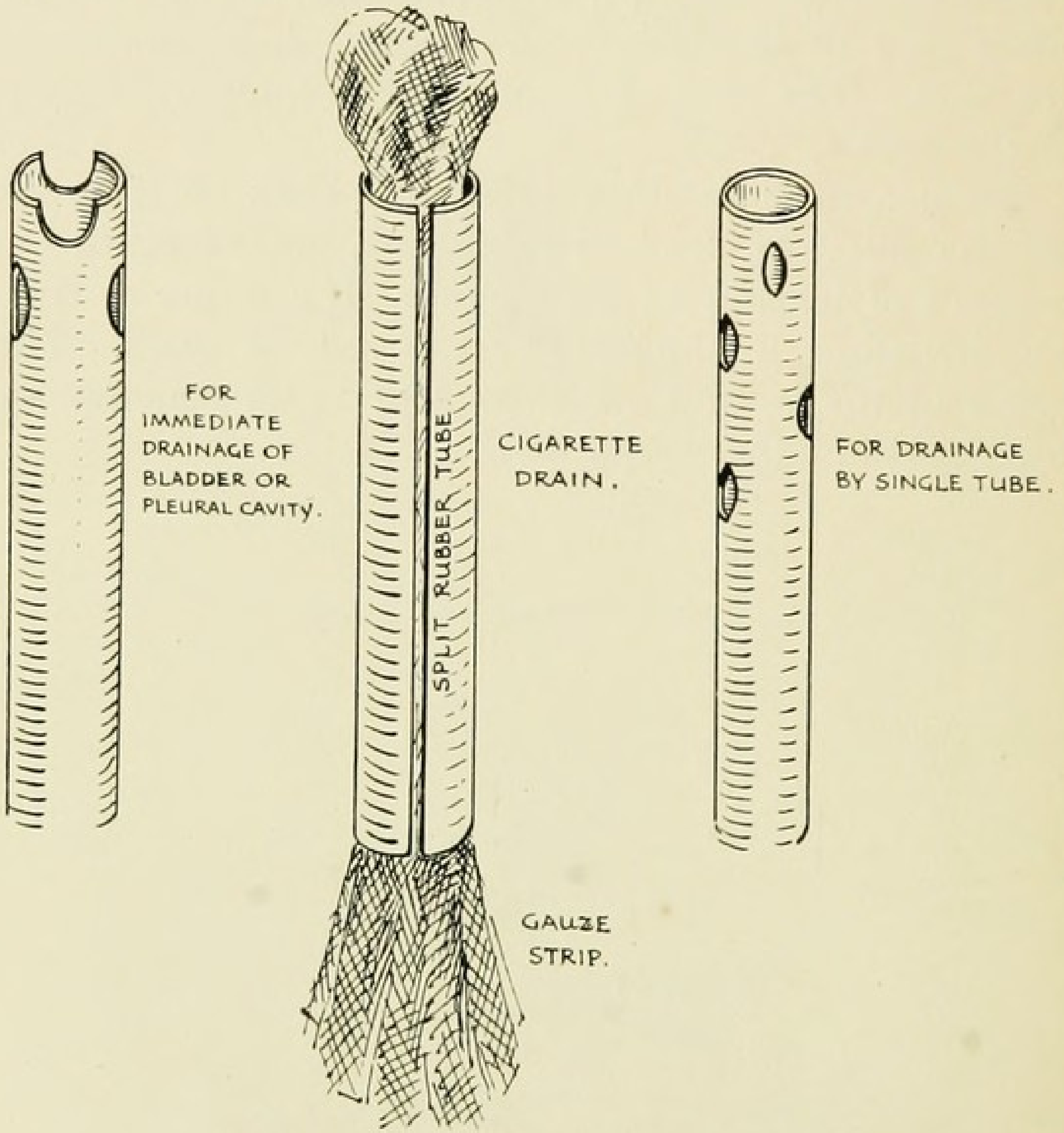


FIG. 38.—Various forms of rubber drainage.

Rubber Tube.—Rubber tubing of different thicknesses is the most usual material used; it may be perforated as in fig. 38, or split down one side. In

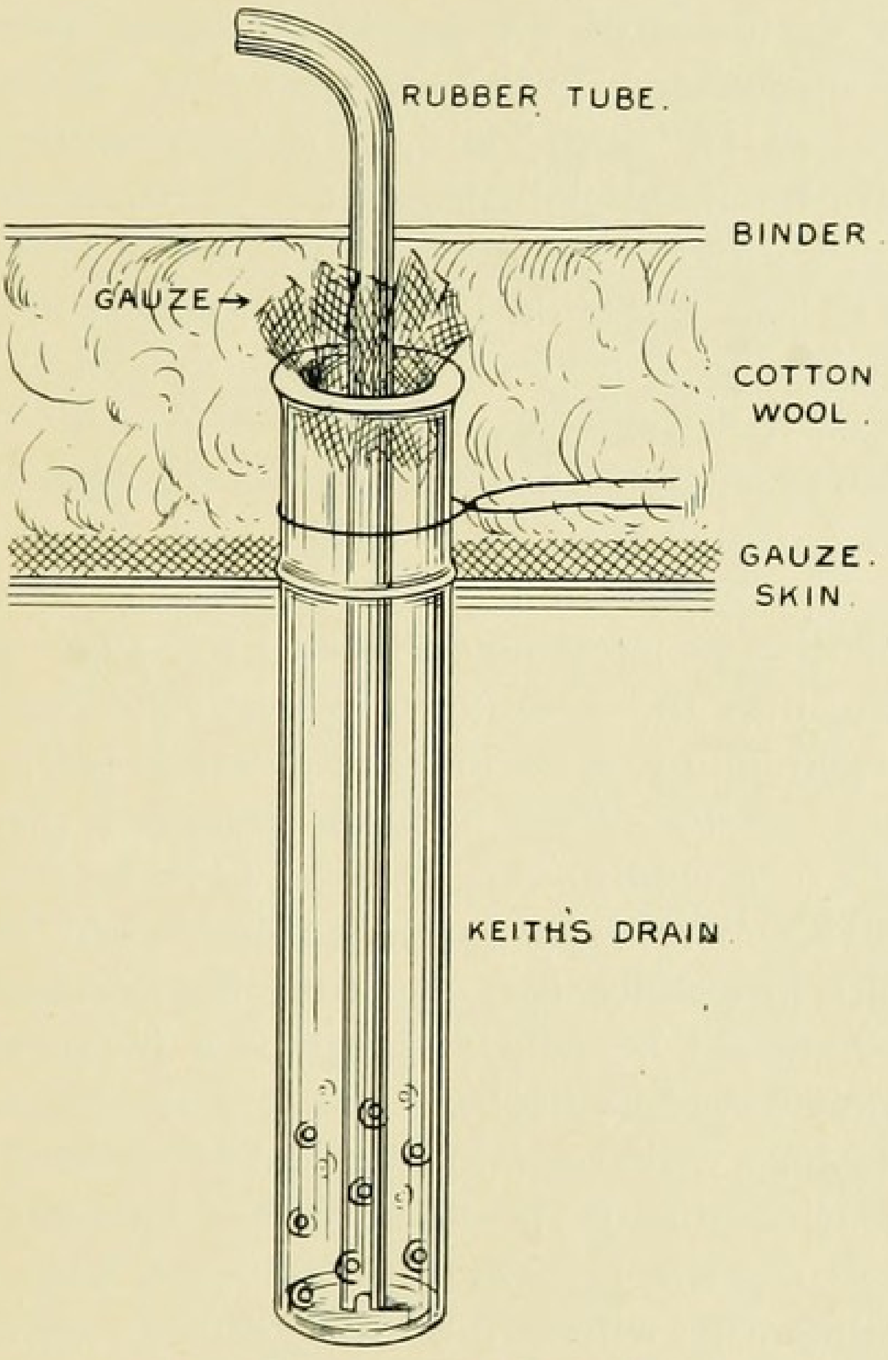


FIG. 39.—Keith's drain.

abdominal work especially, so-called "cigarette" drains are often used. A cigarette drain is simply a split rubber tube with a central loose wick of gauze. The gauze should project about $\frac{1}{2}$ in. from the deep end of the drain. It is rarely necessary to use tubing much thicker than an ordinary lead pencil.

Keith's Drains.—These are made of glass, and are used for drainage of the pelvis (Douglas' pouch) in cases of suppurative peritonitis (fig. 39). The drain is perforated at its "deep" end, as shown in the figure. The holes must not be more than $\frac{1}{12}$ in. in diameter, otherwise hernia of the wall of the bowel may occur through them. Rotation of the tube, which should be done every twelve hours, does not obviate this risk. The fluid which collects in the "well" of the drain is continuously sucked up either by the capillary attraction of a gauze wick or by a rubber tube attached to a suction apparatus, such as Cathcart's. The Keith's tube must be tethered, as shown in fig. 39, to prevent it slipping into the abdomen. A cigarette drain acts, however, equally well and is on the whole safer.

Gauze Tampon.—Where general oozing is present in the depth of a wound, *e.g.*, in bone cavities, or, rarely, after pelvic operations, gauze tampons are inserted. These are primarily for checking hæmorrhage, and therefore should be packed firmly. A favourite form in the pelvis is Mikulicz's tampon. This consists of a sheet of gauze, which is laid over the part where oozing occurs; strips of gauze are then packed into the middle of the gauze sheet, which is gathered into a neck around the strips where they emerge from an angle of the wound. The central strips can usually be removed easily in two days. The neck of the sheet should then be held open and a small quantity of peroxide of hydrogen solution allowed to trickle into the depth; this aids in loosening the gauze. A few twists, first in one direction and then in the opposite, should be given to the collapsed bag of gauze each day, until it comes away fairly easily on the fifth to the seventh day.

Strands of Gauze, Silk, &c.—In certain cases, *e.g.*, in scalp wounds, tube drainage is unsuitable. The compression of the scalp against the comparatively unyielding tube may cause necrosis of the skin. In such cases, therefore, a narrow strip of gauze, or strands of

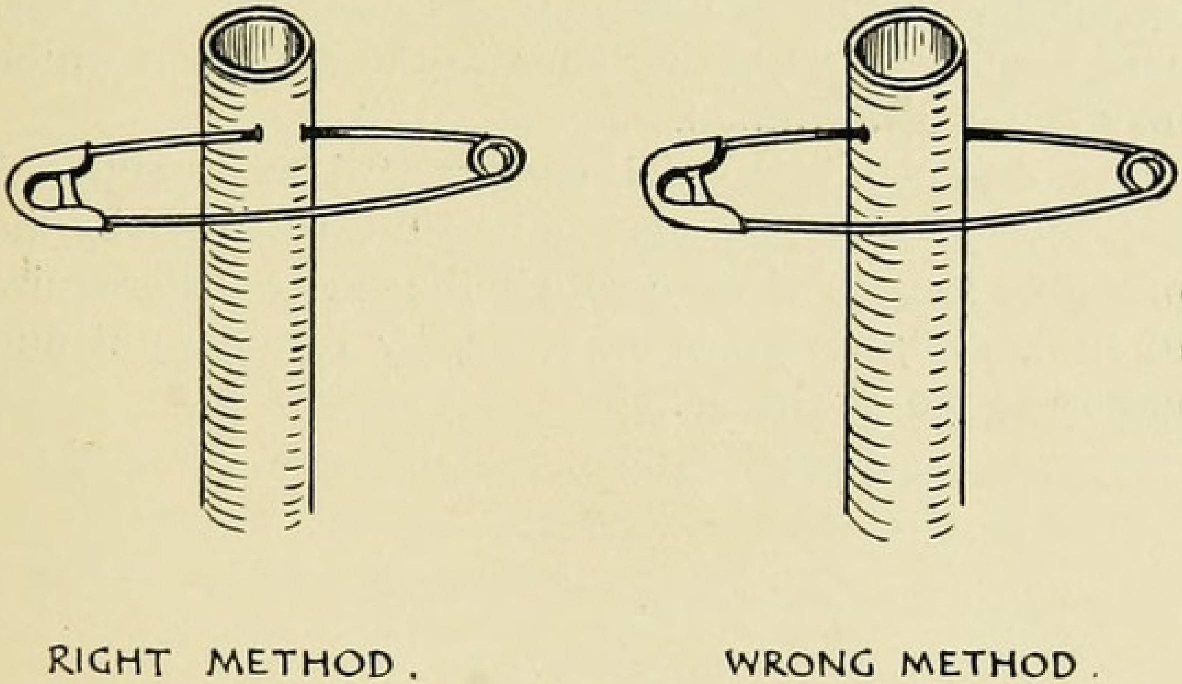


FIG. 40.—Method of inserting safety-pin in drainage tube (see text).

catgut, silk, silkworm gut, or similar material may be used without this danger.

Drains should in all cases be conducted through the deeper layers of a dressing, so that only the superficial layers have to be disturbed when the drains are removed.

A safety pin, fixed as in fig. 40, will prevent a drainage tube from slipping into the depth of a wound.

Removal of Drains.—In acute cases drains should be removed as soon as the discharge becomes thin (serous or sero-purulent). If the pus has been malodorous, it is usually safe to remove the drain when the smell has completely disappeared. It must be remembered that the irritating drain itself will provoke a certain amount of discharge. In certain cases where the drain has gone deep it may be advisable to shorten the drain gradually, say 1 in. every day. In suppurative peritonitis, if there be no smell twenty-four hours after operation, pelvic drains may be removed entirely. This applies also to other sites in the abdomen which may have been drained.

For drainage in special cases see "After-treatment."

In chronic cases one is guided in this matter by the probable length of time which the cavity will require to heal, and, as in acute cases, by the amount and nature of the discharge.

CHAPTER V.

BANDAGING.

The old pedantic rules for the application of bandages have been more or less dropped. Commonsense guides the application in each case. Bandages are put on (*a*) to keep dressings in place, (*b*) for support to a part, and (*c*) for compression.

The methods so carefully described in older textbooks should be thoroughly practised, so as to make one proficient in handling bandages. While no rule of thumb need be followed, the principles above enunciated must be kept in mind, and neatness of finish must not be neglected. Patients judge of the character of work done by final appearances, even of the bandages. A few of the more important forms of bandage are here shown (figs. 41 to 50).

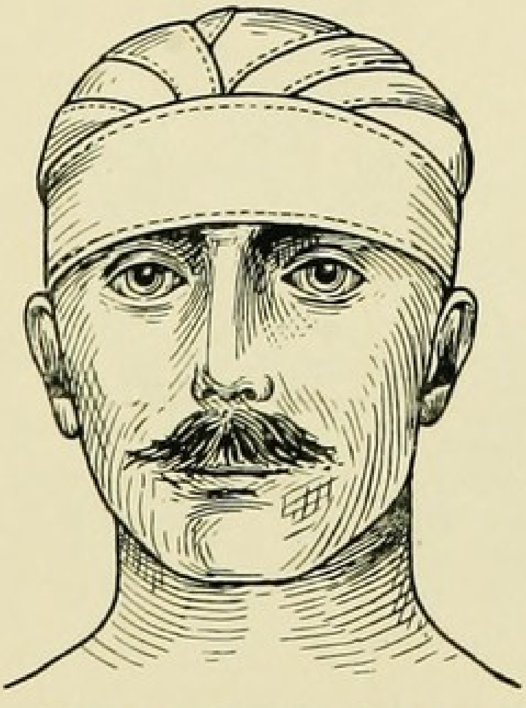


FIG. 41.—Capeline bandage.

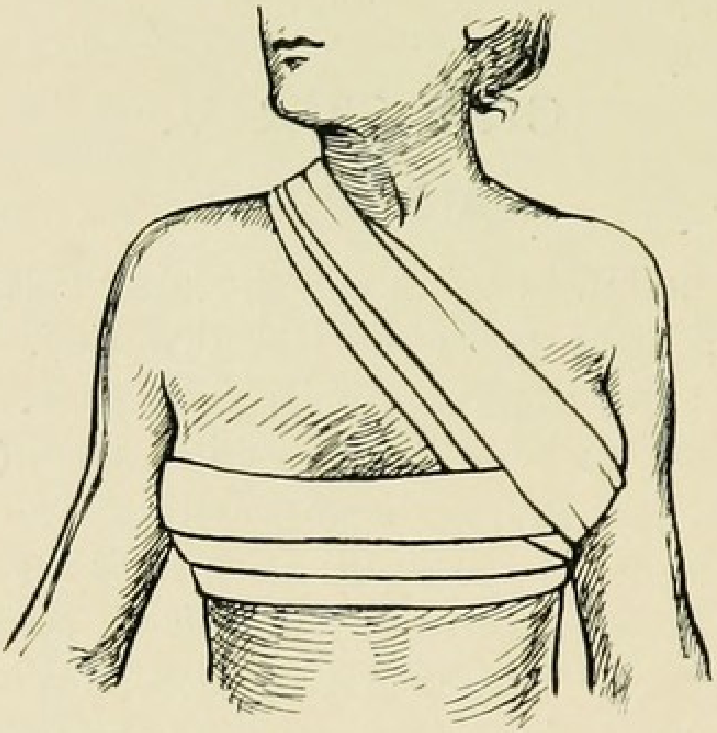


FIG. 42.—For support of one breast.

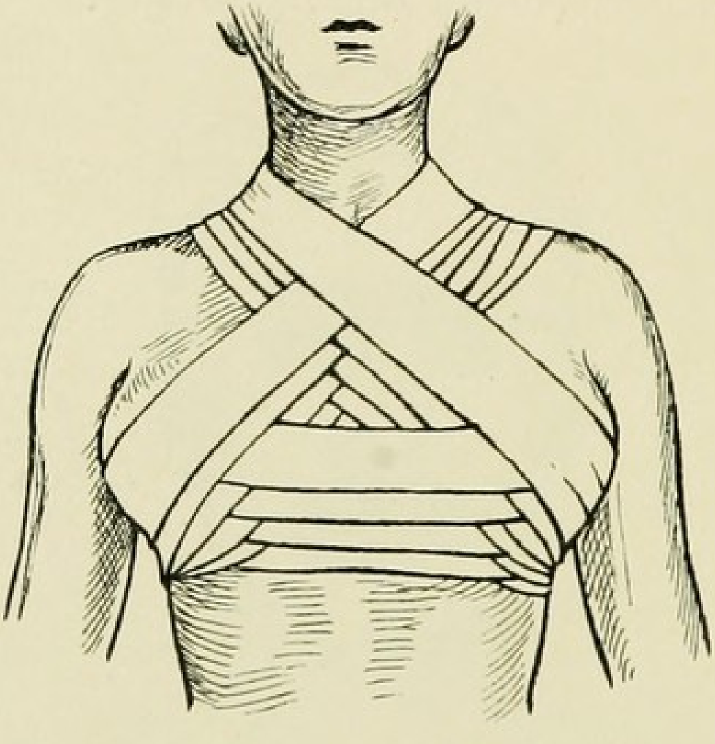


FIG. 43.—For support of both breasts.

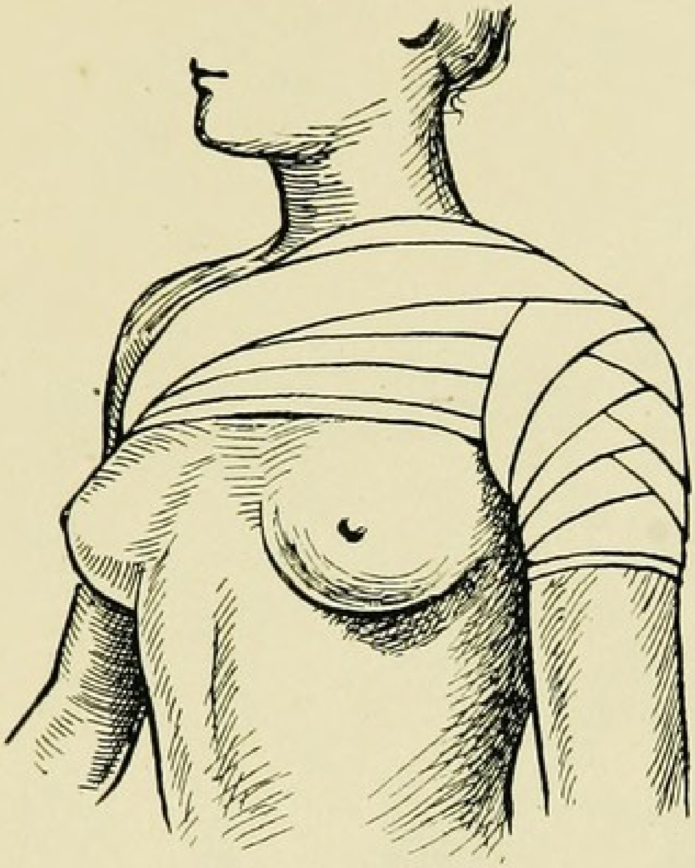


FIG 44.—Spica of shoulder.

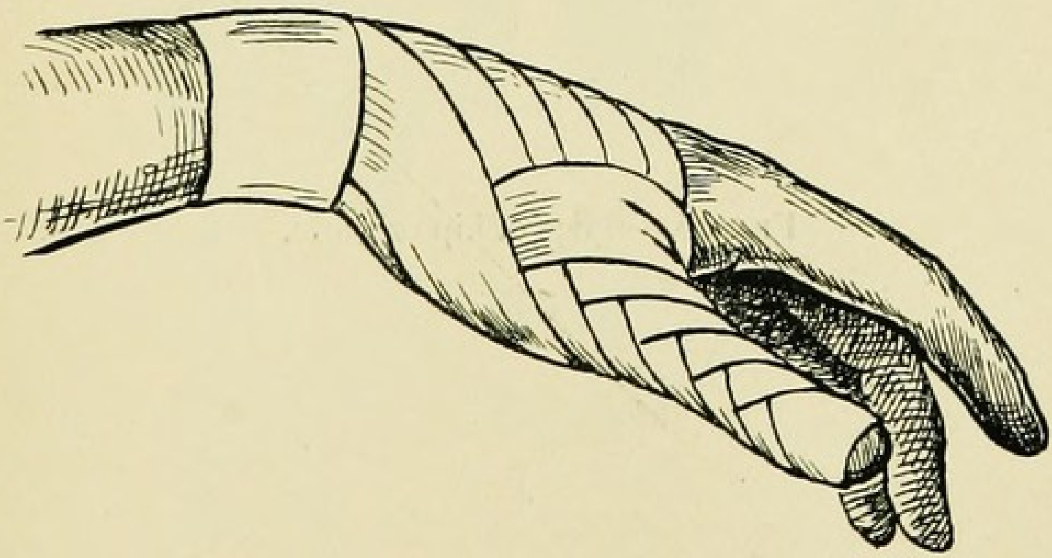


FIG 45.—Spica of thumb.

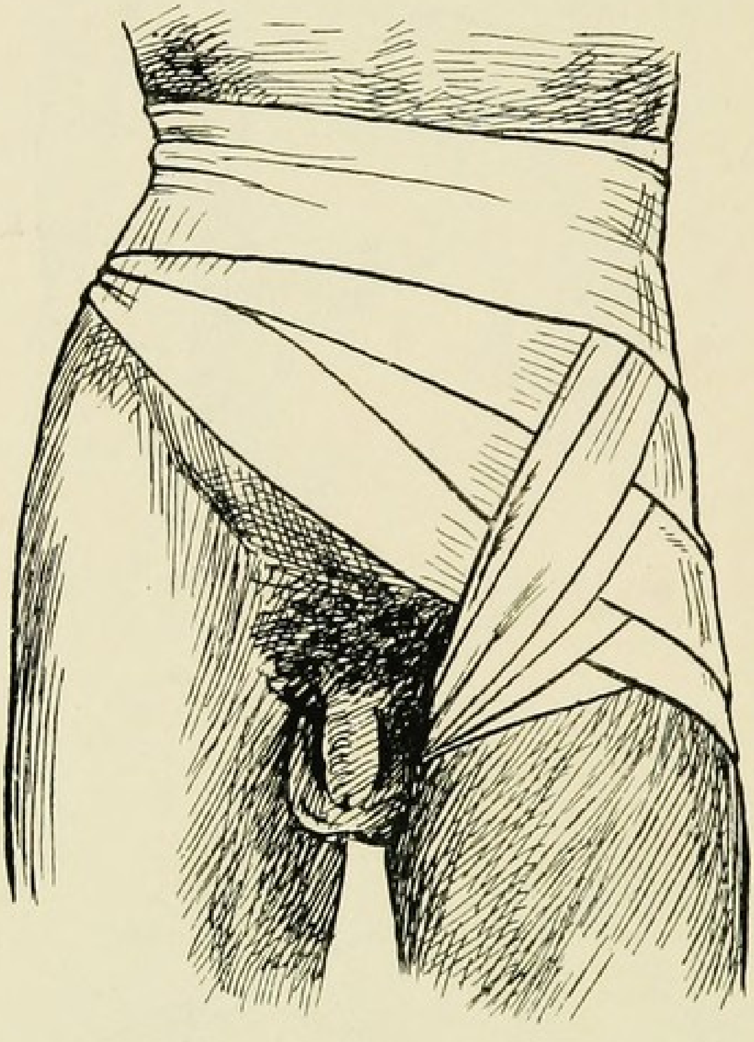


FIG. 46.—Spica of hip or groin.

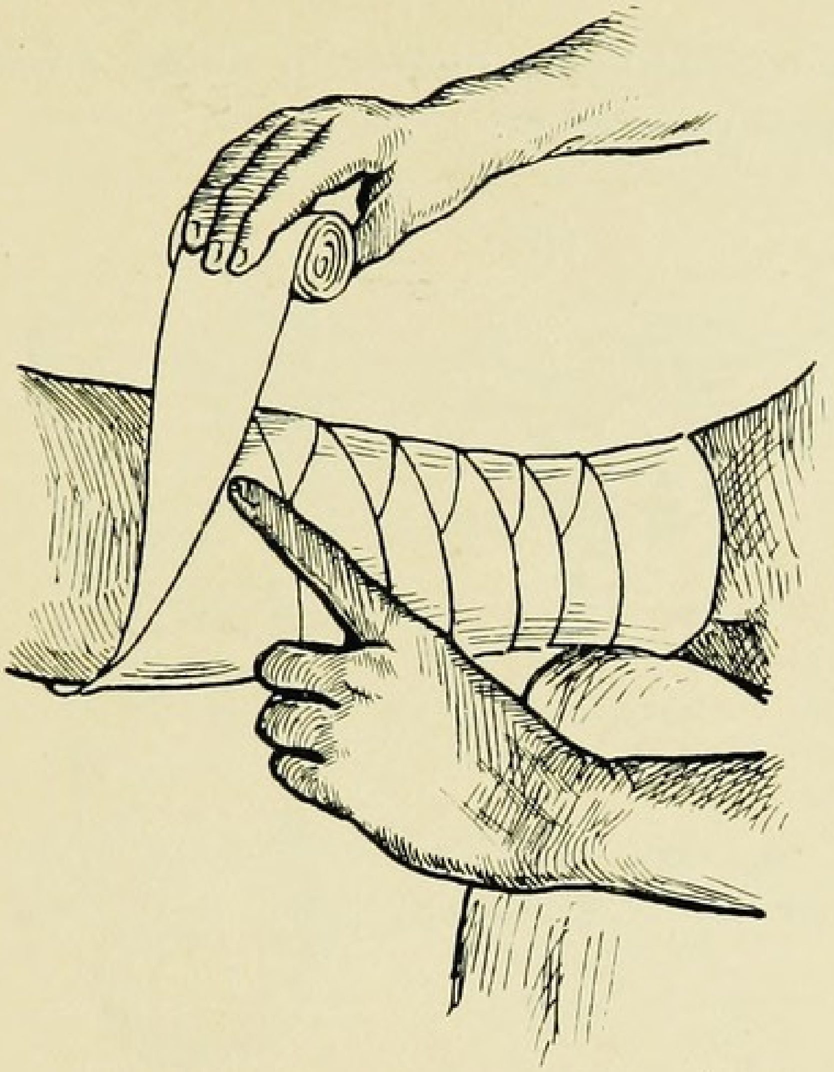


FIG. 47.—" Reverse " bandage.

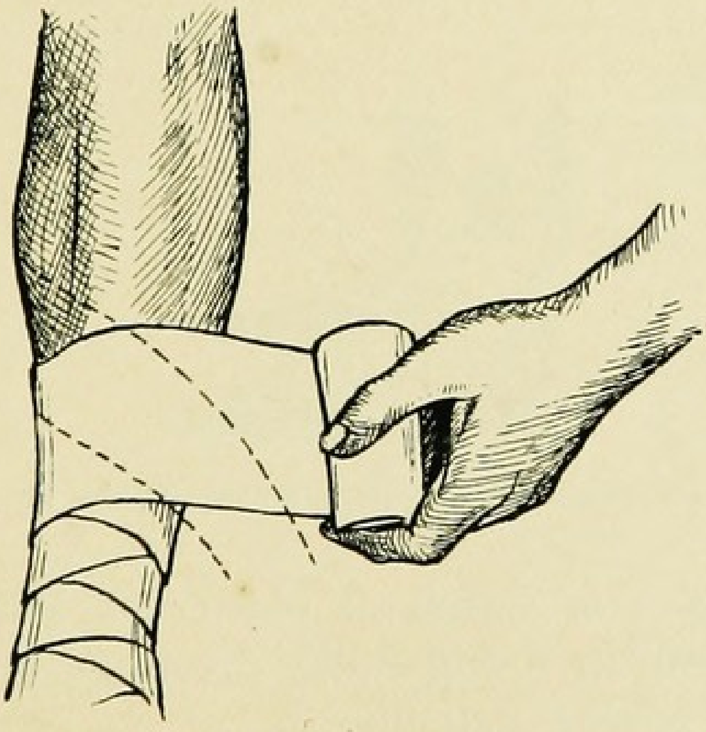


FIG. 48.—" Figure of 8 " bandage.

The use of adhesive plaster in fixing dressings has already been referred to.

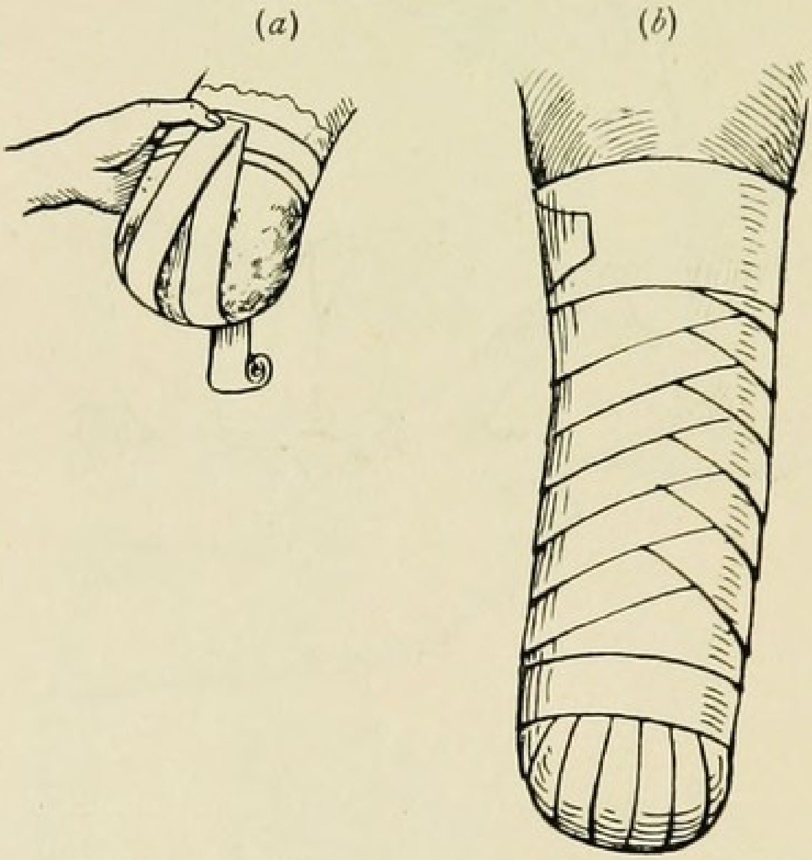


FIG. 49.—(*a*) Stump bandage, unfinished ; (*b*) stump bandage, finished.

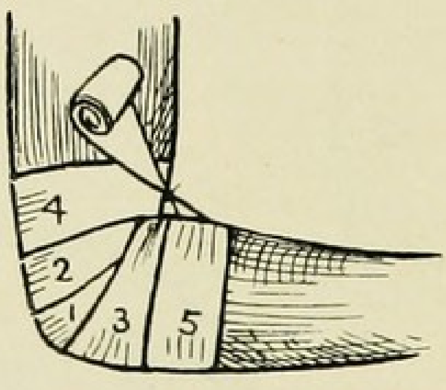


FIG. 50.—Bandage for elbow (in rectangular flexion).

A few layers of starch or plaster of Paris bandage are very useful in fixing bulky dressings on the limbs or heads of restless patients.

While bandaging the hips or shoulders it is convenient to raise the patient on a so-called "pelvic" support (fig. 51). In applying "binders" to the trunk,

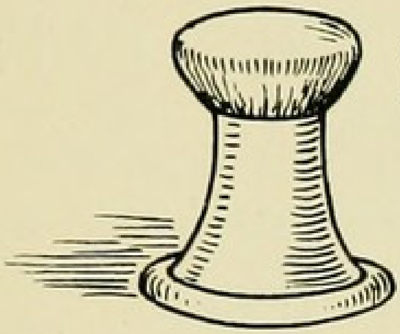


FIG. 51.—Pelvic or shoulder support.

the patient should be rolled over, first on one side then on the other, as the bandage is slipped beneath him.

PREPARATION AND AFTER-TREATMENT OF THE PATIENT

CHAPTER VI.

PREPARATION.

INTERNAL TREATMENT.

GENERAL CONSIDERATIONS.—As regards the influence of diseased conditions upon the risks of operation and the chances of recovery only general statements can be made. Practically all the "systems" in the body have to be considered in connection with the performance of any operation.

Excretory and Secretory Systems. — The excretory system has probably the greatest influence on the ultimate recovery of the patient. Severe operations may be successfully performed, but the patient may succumb sooner or later as the direct result of the interference in cases where excretory or secretory organs are diseased. Of course, in advanced cases of renal or hepatic disorders the immediate risk is great, and in any case there are serious remote risks, due to the low recuperative and resisting powers of such patients, and the danger of complete failure in function of the organ concerned.

Circulatory System.—With regard to the circulatory system, the immediate dangers are more feared, but it is wonderful how patients with pronounced cardiac lesions withstand even severe operations if "compensation" is good. Such patients must be carefully prepared beforehand. Disease of the vessels, which interferes with the accommodating mechanism of the circulation, is even more important than cardiac disease. It is truly said that "a man is as old as his arteries."

Alimentary System.—Diseases of the alimentary tract *per se* have wonderfully little influence on recovery from operations for such diseases. One is struck with the rapidity of recovery when, for example, gastro-enterostomy is performed for pyloric stenosis. This cannot be said, however, with regard to recovery from operations on other parts of the body in such cases. The possibility of evil effects from the anæsthetic, of the inability to take proper food, of the difficulty in regulating the bowels, and so forth, may make one hesitate in advising operation, and in any case make one take particular care to have the *prima via* in as good condition as possible.

Respiratory System.—Respiratory diseases are also of immense importance, especially if the operation interferes with the movements of respiration, *e.g.*, operations in the upper abdomen. The danger in acute diseases is, of course, self-evident, except again where the operation is performed for the relief of such disease. In chronic cases the risks of operation are usually commensurate with the length of time taken in its performance.

In severe respiratory and cardiac disturbances operations should be performed, as much as possible, under local or lumbar anæsthesia.

Nervous and Hæmic Systems.—It is difficult to estimate the effects which mental or other nervous diseases have on the course of an operation case. In these, and in severe hæmic diseases, the opinion of a consulting physician as well as of a surgeon is desirable.

Routine Examination.—It is evident that a thorough routine examination should be made in all cases. Failure to do this will lead, sooner or later, to regrettable experience. One object of investigations made previous to operation, is to find out what special treatment, if any, should be adopted in order to procure quickest and most perfect recovery. Syphilis, gout, malaria, and other constitutional diseases, must be treated by suitable remedies. Disorders of the various systems receive attention as required. In cases of glycosuria and albuminuria extra precautions must be taken because of the danger of delayed healing, liability to inflammation, gangrene, auto-intoxication, anuria, uræmia, coma, &c. In cases of (*a*) glycosuria and albuminuria, in (*b*) debilitated persons, and in (*c*) cases where the likelihood of infection is great, the patient's resistance to infection may be increased by intramuscular injection of suitable vaccines (see later, under "*special cases*"). When much fluid has been lost from the body by hæmorrhage or vomiting, or in cases of emaciation, rectal alimentation or infusion of saline solution, during several days, will give better tone to the circulation.

In a serious case the patient should, if possible, become accustomed to the conditions under which he will be after operation. He should come, therefore under supervision for some days before operation.

Routine Preparation.—An outline of the usual preparation of patients in good condition is: (*a*) Rest in bed for at least one day before operation; (*b*) light diet for a couple of days; (*c*) thorough evacuation of the bowels by a suitable aperient given two days before operation, followed by a simple enema or salts next morning; another enema should be given at least a couple of hours before operation; (*d*) three to four hours before the time of operation some light food, such as tea, or beef tea, Bovril and toast, Benger's food, &c., should be given; (*e*) disinfection of the area of operation (see below).

Care in Feeble.—One must be careful not to tax the energies of feeble patients by drastic purges, or too rigid diet before operation. For a few days they should avoid exertion, indeed remain in bed as much as possible, undergo a course of cardiac and general tonics, and have light, easily digested, and nourishing food.

DISINFECTION OF AREA OF OPERATION.

If possible, the patient should have at least one hot bath, during which special attention is given to the cleansing of the part to be operated on. On the day previous to operation the area to be operated upon is shaved, scrubbed by a soft sterile brush with soap and water, dried, and thoroughly wiped with swabs moistened with some fat-solvent (ether, biniodide in spirit, turpentine, benzine, &c.) A compress, wrung out of weak antiseptic or thick soap-suds, is then applied, covered with some waterproof material such as batiste, and kept in place by a binder or bandage. The area so prepared should be rather more than the area likely to be covered by the dressings which are applied after the operation. The compress should be of a similar extent. For example, for an abdominal section below the umbilicus, the skin of the whole front and sides of the abdomen, external genitals and upper parts of the thighs should be cleansed; for an operation on the knee-joint the whole lower extremity should be disinfected. The cleansing should be done and the compress applied about 5 p.m. If the latter is uncomfortable, it may be removed about 9 p.m., the skin again scrubbed with soft brush or swab, dried, and wiped with fat solvent. A clean garment is then drawn over the part. If the skin is very dirty, the compress may be renewed and left on all night, but if likely to interfere with the patient's rest, this application may be omitted. A fresh compress should be applied two or three hours before operation and removed after the patient is anæsthetized.

In females the hair should be arranged in two side plaits. It is more comfortable for the patient in lying, and is out of the way.

The nurse should always make certain that urine has been voided immediately before the patient goes to the theatre.

The patient is anæsthetized on the transport trolley in the anæsthetic room, and is then wheeled into the disinfection room. Here ward clothing and blankets are removed and sterile garments and sheets substituted; the compress is removed, and the wound area more vigorously scrubbed with a sterile soft brush, soap and water, and dried with a sterile towel. The scrubbing and drying should be begun at the site of incision and continued centrifugally, most attention being given to the site of incision and its immediate neighbourhood. The part is then covered with a sterile towel. The operating table is covered with a sterile sheet, brought alongside the trolley, and the patient lifted on to it. The transport trolley and ward clothing, &c., are taken back to the anæsthetic room. The blankets are placed on the radiator so that they are warm when required at the end of the operation. Meanwhile the patient is wheeled into the theatre on the operating table. Here the towel is removed from the wound area, which is thoroughly wiped with biniodide in spirit (1 to 500), nitric acid in spirit ($\frac{1}{2}$ per cent.), Harrington's solution,[1] or some such antiseptic fat-solvent. The patient is covered with sterile sheet and towels, which are fixed to the *skin* by clips (fig. 52) in such a way that an oblong area

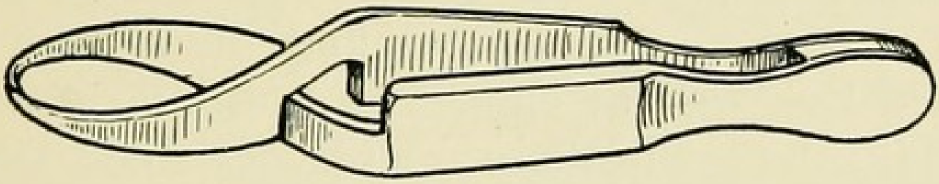


FIG. 52.—Towel clip.

immediately surrounding the site of incision is left exposed. The sheets are broad enough to cover the patient and sides of the table. The clips are turned under the edge of the towel. The operation is then proceeded with.

Exclusion of Septic Foci.—Septic foci existing near the site of incision may be excluded in various ways. The methods here given are modified to suit different cases.

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[1] *Harrington's Solution*—

Methylated spirit	640 c.cm.
Ac. hydrochlor.	60 c.cm.
Hydrarg. perchlor.	·8 gramme.
Water	300 c.cm.

Apply with swab held in a suitable forceps.

(*a*) Where, for example, the abdomen has to be opened in the neighbourhood of a fæcal fistula, the fistula may be plugged with a gauze strip, the area of incision disinfected, and the fistula isolated by *stitching* a piece of sterilized batiste to the skin between it and the incision. The fistula side of the abdomen is smeared with vaseline, covered with cotton-wool, and the batiste then turned over the whole. The sterile towels are laid and fixed over the batiste.

(*b*) Where a superficial abrasion or imperfectly healed wound exists in the neighbourhood of incision, this may be covered by a film of cotton-wool soaked in tr. benzoin co., or celloidin, or by such material as formalin gelatine.[1] A thin pad of cotton-wool is placed over these applications and the aseptic towel is stitched as well as clipped in position. After the operation, the applications above described may be left as a dressing.

(*c*) Parts to be amputated should be covered with cotton-wool to absorb discharges, and surrounded by a sterile towel fixed by clips.

(*d*) In excision of breast, if ulceration of the skin exists, the ulcer should be covered, during disinfection of the skin, by a sterile swab. Thereafter, several swabs should be fixed over the ulcer by sutures (fig. 53).

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[1] 10 to 15 per cent. gelatine, 3 per cent. formalin. Heat the gelatine ; fill a test-tube one-half to three-quarters full, add rather less than one-tenth of pure formalin (40 per cent.), close end of test-tube and mix contents thoroughly by inverting several times. Remove all discharge and fat from the skin ; pour the gelatine on the infected area, and cover with a pad of cotton-wool. The gelatine becomes insoluble and impermeable. The application is very painful and should be done after the patient is anæsthetized.

These absorb the discharge and allow freer manipulation during operation. The same principle is applicable to excision of the appendix where a persistent sinus exists. In this case the sinus is also "packed" with a thin strip of gauze.

(*e*) Small isolated pustules may be cauterized with the sharp point of a Paquelin or galvano-cautery.

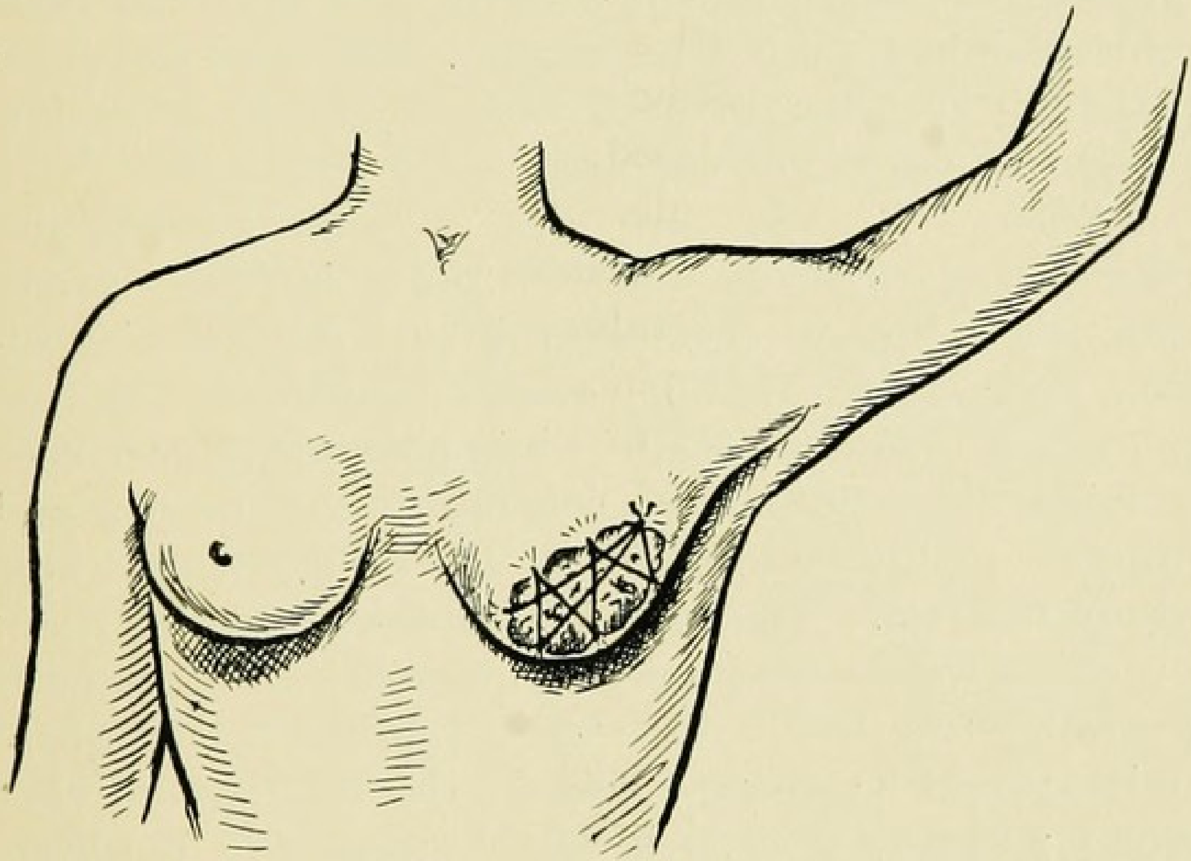

FIG. 53.—"Exclusion" of ulcerating surface during operation on breast.

AFTER-TREATMENT.

The patient is wheeled back to the "disinfection" room, and lifted on to the transport trolley, which has been covered with a warm blanket and stretcher sheet. Blankets, warmed on the radiator in the "anæsthetic" room, are substituted for the theatre blanket, and the patient is taken to the ward or, preferably, to a quiet, darkened room, in charge of a capable nurse, until fully conscious. The bed, suitably prepared for each case, is heated by hot-water bottles or bags covered with flannel. Care must be taken that these bottles are not so hot as to endanger the skin of the still insensitive patient (see "Operation Table"). They should be placed several inches from the body. Thick woollen stockings, and a woollen pad over the neck and shoulders, should be put on. In most cases the patient is laid flat in bed, with the head, on a low pillow, turned to one side.

"Fowler" Position.—In most abdominal cases, and in any case when respiratory trouble is to be feared, the patient should be placed in the "Fowler" position, *i.e.*, propped in a half-sitting posture by bed rest, pillows, &c., and retained in this position by means of a thick, firm bolster placed under the thighs and fastened tightly by means of straps or bandages to the top of the bed. This position is especially important in cases where peritonitis threatens or is actually present. Infective fluid trickles into the pelvis, where it is said to be more efficiently dealt with than elsewhere; at any rate, it is more thoroughly localized, and *may* be favourably acted upon by the greater congestion in the pelvis, due to the posture. The position has a beneficial action in that, by allowing freer (and deeper) respiration, the patient sooner gets rid of the anæsthetic, there is less sickness, he can take food earlier, has less chest trouble afterwards, and altogether has a greater sense of well-being, part of which is no doubt due to his being better able to take interest in what is going on around him.

Shock.—Severe shock is rarely seen nowadays, thanks to better anæsthesia, better preparation, better and more rapid technique preventing loss of heat and of blood, and direct prophylactic measures carried out in cases where shock *might* supervene. Such precautionary measures are, the use of cardiac stimulants (digitalin, spartein, strychnine and adrenalin), firm bandaging of limbs and, more especially, of abdomen, and the use of saline infusion. If shock seems imminent, the infusion should be made subcutaneously, or preferably intravenously. It is given slowly until the pulse again becomes of good quality (see "Infusion and Transfusion").

Pain.—Severe pain must practically always be counteracted by the use of morphia or some derivative of opium. If there be no sickness this is given in small repeated doses, either by mouth or hypodermically. In abdominal cases the use of opiates is to be deprecated.

Vomiting.—Post-operative vomiting is, like shock, less frequent, and for similar reasons. If it is persistent, one should try the "Fowler" position, that failing—the effect of large draughts of tepid water with sod. bicarb., 10 to 20 grains. This washes out or counteracts irritative secretions in the stomach.

Other remedies for vomiting of this description which have been vaunted from time to time are of doubtful value. Such are, tr. iodi, cerium oxalate, ac. hydrocyan. dil., morphia, &c. Morphia in some cases actually seems to bring on vomiting. If given it must be in a fairly large dose ($\frac{1}{4}$ to $\frac{1}{2}$ grain), rather than in frequent small doses. In persistent cases, however, every available remedy may have to be tried. Sulphate of eserine, $\frac{1}{50}$ gr. hypodermically, often acts like a charm ! In such cases where, in addition, the pulse becomes quick, feeble, and irregular, the temperature is raised, thirst is intense, the complexion becomes yellowish, the liver tender, the abdomen perhaps distended, and the urine scanty and containing acetone, the diagnosis of "delayed" chloroform poisoning is manifest. This is especially apt to occur in septic cases, and, according to many authorities, especially in children. Here, again, the best treatment is prophylactic. Try to prevent the condition from developing by giving, in cases where it is to be feared, or where incipient symptoms are already present, large doses of alkali by the mouth, by the rectum, or by the other methods of infusion if vomiting be present. Glucose (5 per cent.) may be added, with advantage, to the infusions. In septic cases the anæsthetic given should be ether.

Thirst.—Thirst is frequently troublesome. One tries to treat patients after operation as naturally as possible, therefore when thirst is present, if there be no contra-indication, let them have plenty to drink, slowly—weak tea with little milk and no sugar, soda water, milk and soda, barley water, plain boiled water, &c. In many cases interrupted or continuous rectal infusion has to be resorted to.

Retention of Urine.—In operations about the pelvis or upper parts of the thighs, especially on the anus and perineum, retention of urine, for a very variable period, is not uncommon. This usually necessitates the use of the catheter. For children one has not always a suitable size of catheter handy, and it will be found that on administering a few drops of chloroform urine is voided.

SPECIAL CASES.

(1) NOSE, MOUTH, OR THROAT CASES.

Preparation.—Oral sepsis remedied. Tongue brushed and scraped, mouth-washes, aperients. Decayed teeth extracted or cleaned, tooth-brush, antiseptic powder (*e.g.*, betanaphthol). Nasal discharges treated. Enlarged tonsils, adenoids, polypi, &c., removed.

Prophylactic injections of staphylococcic (500 millions) and streptococcic (250 millions) vaccines one week before operation.

After-treatment.—Fowler position. Rectal alimentation. Frequent careful cleansing.

(2) CRANIAL CASES.

Preparation.—Whole head shaved and cleansed. Avoid previous use of morphia or bromides as much as possible. Special attention to bowels.

After-treatment.—Quiet; darkened room; Leiter's tubes, rather than cold compresses; remove drains early; avoid stimulants; early aperients; light but nutritious feeding.

(3) OPERATIONS ON LIMBS.

Preparation.—Special care in disinfection of skin over joints. For fractures, varicose veins, &c., shave the whole limb.

After-treatment.—Fixation by splints or plaster of Paris. Early passive movements and massage, especially where joints affected. After operations on veins immobilize from ten to twelve days; no massage.

(4) FOR COMPLETE BREAST OPERATIONS.

Preparation.—Disinfect side and front of neck, shoulder and arm, chest across to opposite nipple down to umbilicus and round to spine. Special attention to axilla.

After-treatment.—Tube through small incision in posterior axillary fold, reaching towards axilla, but clear of vessels and nerves. Reconstruct axilla by careful padding so as to compress skin into apex against chest wall and inner arm; binder round chest; shoulder spica; no splint or sling required; forearm on pillow; "Fowler" position; remove tube on second day; allow use of arm from the first.

(5) EMPYEMA.

Preparation.—Local anæsthetic preferable.

After-treatment.—Drainage tube thickness of thumb, notched at end (see fig. 38), projects not more than ½ in. through parietal pleura. Parietes stitched snugly round tube, which is fixed by a suture, and conducted through dressings to large bottle, containing antiseptic, at side of bed. Coughing expels air, fluid thereby sucked up in tube causes intrapleural negative pressure. When discharge down to 2 oz. in twenty-four hours remove tube. Apply 3 in. square of protective over wound. Encourage expansion of lung by deep respiration, whistling, blowing through James' bottle, &c. Probe occasionally to ascertain that no pus is being retained.

(6) ABDOMINAL OPERATIONS.

Preparation.—When there is much fear of infection to peritoneum at operation, prophylactic doses of staphylococcic (500 millions), streptococcic (250 millions), and *Bacillus coli* (200 millions) vaccines. In inflammatory cases, "Fowler" position before as well as after operation. To clear bowels use chiefly castor oil, salts, and enemata.

GASTRIC CASES.

Frequent gastric lavage in gastrectasis; sterilized diet. During the night previous to operation the patient has a meal of sterilized milk or Benger's food. Wash out stomach an hour before operation with weak boric or Condy's solution; saline infusion per rectum for a day or two in some cases.

After-treatment.—If no sickness, dessertspoonsful of tepid sterile water every hour after operation. Double quantity next day, Somatose or Plasmon added. Albumen water (whites of four or five eggs to 1 pint of water). Third day, milk and soda, thin Benger's food, chicken tea; 1 oz. every two hours; weak tea. Fourth day, 2 oz. every two hours. Fifth day, 3 oz. every two hours. Sixth day, 4 oz. every two to three hours. Seventh day, 4 oz. every two to three hours; milk pudding, chicken cream, pounded sweetbread, &c., sponge finger biscuits. Eighth day onwards, gradual progress through light to easily masticated ordinary food by fourteenth day. Rectal saline infusion continuous, or 10 to 20 oz. every three to four hours for first two to three days; gradually decrease as the amount by mouth increases. Aperients: enema on third day, and every second day thereafter until aperients by mouth on fourth to seventh day, according to the nature of the operation.

INTESTINAL CASES.

After-treatment. — Similar to above. Where artificial anus present, normal diet and aperients can be given earlier.

OTHER ABDOMINAL CASES.

Light or ordinary diet given as soon as appetite desires it. Aperient not later than third or fourth day calomel (1 grain) every hour for five hours, less if bowels move, followed if necessary by magnes. sulph., a teaspoonful in hot water in the morning; if no action of bowels, turpentine enema at 10 a.m.

The tendency in recent years has been to allow such cases out of bed much earlier than formerly. The effect of this greater freedom is to show a decreased number of cases of thrombosis and embolism. As a rule, cases of operation on the upper abdomen can get up much earlier than those on the lower abdomen. The writer has found no bad results to follow the practice of allowing patients out of bed well within the week, in cases where muscular or aponeurotic fibres have not been divided but only separated, the one exception being in the case of hernia, where patients are usually kept in bed for three weeks.

(7) HÆMORRHOIDS.

Preparation.—Aperient two days before operation. Light diet on day before, and repeat aperient ($\frac{1}{2}$ oz. ol. ricini) on afternoon (5 p.m.) before operation. Simple enema at midnight. Two hours before operation rectum washed out with boric solution; patient sits up and strains to empty rectum.

After-treatment.—Morphia suppository ($\frac{1}{4}$ to $\frac{1}{2}$ gr.). Fluid and light diet for a week. On evening of second day after operation inject 3 to 6 oz. of warm olive oil, and give 1 oz. ol. ricini by mouth; if no action by 10 a.m. give simple enema, thereafter aperients every second day. Carefully wash external parts after each motion.

(8) PERINEORRAPHY.

Practically the same as for hæmorrhoids, with the addition of antiseptic vaginal douches before operation.

(9) OPERATION ON GENITO-URINARY ORGANS.

Preparations. — Internal administration of salol, urotropine, ac. benzoic., or ac. sod. phosph, &c. Wash out bladder with antiseptics to render urine and bladder as "pure" as possible. If urine very offensive from ammoniacal decomposition, and if above fails, large doses of freshly prepared sod. citrat. (20 to 40 grs.) may succeed in rendering it less irritating. Prophylactic injections of vaccines, as in abdominal cases, may be useful, especially in feeble prostatic cases.

After-treatment.—Continuance of antiseptics; occasional washing out of bladder if necessary; large draughts of bland non-irritating fluids. Rules as to drainage vary greatly according to different operators.

CHAPTER VII.

OPERATIONS IN PRIVATE HOUSES.

Much has been said as to equipment and general arrangements for operations in hospitals. This is very necessary, because when many operations are performed in succession the work is made much easier and the results more certain by those means. Excellent results, however, can be obtained in private houses with simple makeshifts, provided that uniform care, under guidance of a well-developed "aseptic conscience," be exercised.

Operations in private houses are becoming more infrequent every year, owing to the spread and development of nursing homes, cottage and general hospitals, and the inclination of patients to take advantage of them. In cases in which the patient cannot or will not be transferred to such an institution, it is necessary to know what, and how, to prepare so that the operation may be carried out under as favourable conditions as possible.

THE SURGEON'S RESPONSIBILITIES.

Complete Outfit.—The surgeon brings certain articles with him. A complete outfit includes a portable operating table, of which there are many excellent patterns; drums filled with sterilized overalls, masks, &c., sheets, towels, swabs, dressings and bandages; instruments, sutures, and ligatures; and a special "surgeon's" bag, containing a nondescript collection of articles, which will be more minutely described later.

A practitioner, in requesting the services of a surgeon from a distance, should always indicate as clearly as possible the nature of the case; the surgeon can then prepare more certainly for eventualities which may occur. It is very perplexing to receive such a telegram as "Come at once, operation case"! This is not an unheard of message.

Drum with Sterilized Articles.—A drum (10 in. by 13 in.) will hold from below up: three to four bandages, binder, a reasonable quantity of cotton-wool, gauze dressing, gauze strips, four large abdominal pads, folded gauze bag containing four dozen swabs, one large operation sheet, six towels, three overalls, six nail-brushes, two towels, and a few loose swabs. These are all packed inside a fourfold sheet of gauze, which lines the interior of the drum, and is folded over the top of the articles.

Leather Case for Drum.—The sterilized drum is covered during transport by a close-fitting, well-sewn, strong leather case, the lid of which should have a broad, overlapping margin.

Surgeon's Bag.—The "surgeon's" bag, measuring about 18 in. by 9 in. by 10 in., should be made of strong cowhide, have a removable and *sterilizable linen lining* fitted with large pockets on one side, and compartments on the other for small bottles, hypodermic case, razor, tube of ointment, spare tube of silk ligatures, nests of trocars, thermometer. The small bottles contain compressed drugs or solutions for local anæsthesia and antiseptics, adrenalin solution.

The hypodermic case should contain "tabloids" or tablets of strychnine, digitalin, morphine and eserine.

The pockets contain a sterilized Higginson's syringe, two or three sizes of drainage tubing, adhesive plaster, hair clipper, tracheotomy tubes, Murphy's buttons, mouth-gag, and a tongue-forceps.

On the bottom of the bag lie boxes containing ampoules of sodium chloride, rubber gloves, ampoules of novocain for spinal anæsthesia, spinal anæsthesia syringe, large syringe for local anæsthesia, and short, thick, glass-stoppered bottles containing a supply of turpentine soap and a solution of biniodide in spirit.

Instruments, Ligatures, &c.—The instruments, ligatures, and sutures may be sterilized at the surgeon's home, placed in a sterile towel, which is folded carefully over them and rolled up. This is rolled again in a second large towel and placed in the bag.

Masks, Aprons, Saline Apparatus, Control Strap.—(1) Caps and masks, (2) aprons, (3) saline infusion apparatus, (4) strap of webbing for control of patient's knees are pinned into separate towels, labelled, sterilized, and placed in the bag. (The glass nozzles of the saline apparatus are protected by cotton-wool.)

If the operator prefers to sterilize his instruments at the patient's house, he must carry a portable sterilizer as a separate package.

Electric Head Lamp.—An electric head lamp and an accumulator should be carried for night operations.

THE PRACTITIONER'S RESPONSIBILITIES.

Message to Consulting Surgeon.—The message to the consulting surgeon should not only be clear and concise with regard to the nature of the case, but should mention whether an anæsthetist, nurse, or other assistant is required.

Nurse.—A fully trained nurse should be procured, if possible, a day or two before the operation, so that the patient may become accustomed to her.

Conveyance for Surgeon.—If the surgeon does not come by his own conveyance, arrangements should be made for a carriage to meet him, so that no time may be lost in dealing with an urgent case.

Selection of Room.—The room for operation should be, if possible, large, airy, well lighted and heated, and where practicable, a room, other than the patient's bedroom, but on the same floor, should be chosen.

Bed.—It may be advisable to have the patient nursed afterwards in the room selected for the operation. If so, a suitable narrow bedstead with firm mattress should be obtained, and made ready on the evening before.

In cases of fracture, boards placed under the mattress may be required (fracture boards).

Remove unnecessary Furniture.—The carpet should be taken up and all unnecessary furniture and hangings removed.

Wash Floor. — The floor and skirting should be washed with some antiseptic. The window sashes should be wiped with a cloth moistened in antiseptic and if the windows be overlooked clean muslin curtains should be put up.

Protect Floor.—The floor where the operating table is to stand may be covered with sheets of mackintosh material, brown paper, or ordinary newspapers. These are covered with a clean drugget or sheet.

Necessary Furniture.—A small table (4 ft. by 2 ft.) for instruments, a larger table for four wash basins, a small table for two lotion basins, a wooden chair for the drum, a chair and small table for the anæsthetist, make up the necessary furniture. Substitutes for these in the shape of sideboards, dressing tables, &c., from which all ornaments are removed, will occur to the mind of the practitioner. All tables, &c., to be used should be thoroughly washed with antiseptic lotion; each is covered with a clean sheet or towel shortly before the hour of operation.

In very Urgent Cases "Let sleeping dogs lie"!—If time does not permit, such preparations are inadvisable, because they stir up dust. Ornaments and light articles of furniture may be removed, otherwise as little as possible should be done. The floor is covered as already described; sheets may be spread over such articles as sofas, revolving bookcases, and the like. Mantle-shelves, dressing and toilet tables, window-sills and sashes, are wiped with a cloth moistened in antiseptic. No dry dusting by nervous, fussy people should be allowed. Necessary furniture as before.

Sterile Water.—It is wiser to have too much than too little of this commodity! Six or eight large bedroom water jugs (ewers) or hot-water cans should be scalded, or preferably sterilized, by the nurse or other capable person.

Sterilization of Water Jugs, &c.—The sterilizing of both water and jugs may be carried out in the washhouse boiler, if such be available. Of course both utensils and boiler should be previously cleaned. If there be efficient hot-water circulation in the house, the articles may be scalded in a bath and then filled from the *boiling* water tap; otherwise the water must be boiled in kettles or pots, the latter being freed from grease by being thoroughly scrubbed with washing soda and rinsed with hot water. The jugs or cans should be placed in the operating room on a clean towel and covered with a clean towel. Three such jugs or cans are filled overnight and form the supply of cold sterile water; the other three are filled shortly before operation with boiling water.

Rapid Cooling in Emergency.—If necessary the water may be cooled by carefully placing the jugs of boiling water in a bath or tub filled to a suitable depth with cold water.

Basins.—Four large and two small basins, preferably enamelled, should suffice. These are treated in the same way as the jugs or cans for sterile water. If sterilized in the bath or wash-house boiler, they should previously be wrapped in a towel or sheet, and be lifted out tilted sideways, so that excess of water may drip away. They may be prepared on the night before and kept covered with a clean towel.

Blankets and Waterproof-Sheets must be provided for covering the operating table and patient.

Bed-rest or Extra Pillows for Fowler Position.—If the case be an abdominal one, a bed-rest or half a dozen pillows and a bolster should be provided, so that if necessary the Fowler position may be assumed after operation.

Receptacles for Soiled Water or Linen. — Two receptacles, one for dirty water the other for soiled swabs, linen, &c., should be provided. Ordinary clean household pails are quite suitable.

Hot Bottles.—A liberal supply of hot bottles should be placed in the bed a few minutes before the operation is commenced.

Three or four sterilized wooden nail-brushes should be placed in the lavatory or its substitute.

In certain cases the above must be modified, and common-sense will guide one in the selection of make-shifts. In general practice it may be found convenient to use an ordinary large fish-kettle as a sterilizer for instruments and also for towels, a supply of which may be boiled and transferred to a sterile basin, where they are covered and allowed to cool; when required for surrounding the area of operation, excess of water is wrung out of them. The patient's clothing must be protected by mackintosh or sheets of clean paper, underneath the towels. Sterile gauze cut into lengths serves as swabs.

Preparation of Patient.—All arrangements for operation must be carried out with as little disturbance as possible to the patient. External preparation of the patient is alone described at this stage; details of internal treatment have been discussed ("Preparation and After-treatment").

Bath.—It is advisable that a full warm bath be given, special attention being directed to the area of operation and its neighbourhood, which is well lathered with soap. On the night preceding operation, a large area around the probable site of incision should be shaved, thoroughly washed, and scrubbed with a swab moistened in ether, alcohol, or other fat-solvent, and a correspondingly large warm compress applied.

Compress over Operation Area.—This compress consists of fourfold lint, or similar material, wrung out of weak antiseptic solution or thick soap-suds. After application it is covered with some water-proof material and kept in position by a binder or bandage. On the morning of operation the skin is again washed with soap and water, fat-solvent, &c., and the compress renewed.

Consultation with Surgeon.—The practitioner should endeavour to meet the surgeon on arrival, and tell him the history of the case, the diagnosis he has made, any idiosyncracy in diathesis peculiar to the patient or his family he may be acquainted with, how much he has told the patient of the nature of his ailment, and any further particulars requisite for the better management of the case. If, after consultation, operation is decided on, there should be no delay in carrying it out, provided that the above preparations have been made.

Unpacking and Preparation outside Operation Room.—All unpacking (table, &c.) with the exception of the "surgeon's" bag, should be done outside the room. Aprons are put on. Preliminary disinfection of hands is carried out in the ordinary lavatory basins if possible.

Preparation in Operation Room.—The nurse should arrange three prepared basins filled with warm sterile water and one with warm antiseptic lotion, in a row on a table reserved for them. The nurse opens the sterilized drum and the surgeon picks out the nail-brushes, dropping one into each basin. He then scrubs his hands and forearms in the sterile water, passing from one basin to another, finishing with the antiseptic lotion. No soap is used in this series. The nurse places the towel containing the instruments on the instrument table and unfolds the outer towel. She then unfolds the towel containing the masks and caps, which are put on as described. The surgeon's overall is next adjusted.

Transport and Anæsthetizing of Patient.—During this time of preparation, the patient has been brought into the room. If unable to walk, he may be previously anæsthetized. The assistant delays final disinfection in order to assist with the transport of the patient to the operating table ; while so doing he should protect his hands with a clean sheet or towel. The strap for controlling the patient's knees should be adjusted. The commencement of anæsthesia should correspond with the finishing of the surgeon's disinfection, so that a nervous patient may not see him in any alarming costume !

The nurse now pours biniodide in spirit into a small basin and places it, along with another basin containing weak antiseptic solution, in a position easily accessible to the surgeon during the operation if occasion demands. The surgeon unfolds the towel surrounding the instruments, arranges the instruments, prepares ligatures and sutures, and covers the whole with a sterile towel. The nurse, meantime, changes the sterile water in the basins. The assistant having again washed his hands, scrubs them in sterile water and lotion in the same way as the surgeon.

When the patient is fully anæsthetized, the nurse lays bare the field of operation, scrubs it with soap and water, and the surgeon or assistant dries the part with a sterile towel. The skin is then vigorously wiped with sterile swabs soaked in biniodide or acid in spirit. The site of incision is surrounded by sterile sheet and towels (see p. 301). In abdominal cases the patient's legs are slightly separated to make a hollow in which the instruments and bag of swabs are placed.

The operation is then proceeded with.

PART IV.

CHAPTER VIII.

Abridged Descriptions of

EMERGENCY OPERATIONS

Which may have to be undertaken by a Medical Man in General Practice.

These procedures are described as shortly as possible so that, if necessary, the memory of the practitioner may be refreshed as speedily as possible before the operation is undertaken.

Herniotomy: (*a*) strangulated inguinal hernia; (*b*) strangulated femoral hernia.

Tracheotomy.

For compound fractures.

Amputations.

For contused, incised and lacerated wounds.

For punctured wounds of chest and abdomen.

Excision of localized superficial tumours.

For burns and scalds.

Exploratory puncture and paracentesis.

For certain acute abscesses.

Infusion of saline solution.

HERNIOTOMY.

Strangulated Inguinal Hernia.

Anæsthesia.—General preferable, but if assistance be inadequate, or patient in feeble condition, local.

Instruments.—Scalpel; two scissors, blunt pointed, curved and straight; ten to twelve artery forcipes; two dissection forcipes; hernia knife and hernia director preferable but not absolutely necessary; blunt hooks; retractors; ligature and suture material; needles—two ordinary fully curved, one fully curved rounded, one curved handled, two intestinal needles, straight or fully curved.

Technique.—Shave lower abdomen, pubic region, scrotum and groin. Incision 3 in. long, parallel to and a finger's breadth above Poupart's ligament, upper limit extending well beyond tumour. The incision is carried down till easily recognized glistening fibres of external oblique aponeurosis seen. Bleeding points secured. To beginners, Scarpa's fascia (sometimes very well marked, especially in children) constitutes a difficulty, being not infrequently mistaken for aponeurosis. Define external inguinal ring and from here slit external oblique aponeurosis in long axis of fibres till clear of sac. Catch edges of aponeurosis with artery forceps and retract gently. With two dissection forcipes tear through the remaining coverings of the sac, commencing at inguinal canal. These coverings are cremasteric and transversalis fasciæ. Retract edges; expose sac; insert finger and isolate sac by manipulation. Enlarge opening in external coverings downwards and inwards if necessary. Open sac by picking it up with dissection forceps and snip small hole with blunt-pointed scissors. Enlarge opening with scissors sufficiently to inspect contents. Edges of sac are clamped by artery forceps and held aside. If free fluid in sac, swab and wash out with sterile saline solution. Free neck of sac. Slit constriction either from without in by dissection, or from within out by passing hernia or other director carefully through it at upper part and nicking with hernia knife, scalpel or scissors passed along the groove. Injury to bowel must be carefully avoided. Now draw down contents. If adhesions prevent this they must be carefully separated by blunt dissection, with closed scissors or handle of scalpel. Here and there a slight snip is sometimes necessary. Examine bowel carefully for evidence of interference with circulation. If simply purple from congestion, natural colour rapidly reappears. If discoloured from ecchymosis it may be difficult to distinguish from gangrene. Simplest test is to make superficial incision—through peritoneum—which bleeds if circulation be still intact, in which case close incision with fine silk intestinal suture, wash with sterile saline solution and return to abdomen. If omentum present return or pass double catgut suture with rounded needle through middle of stump and tie each half separately, interlocking ligatures. Cut off omentum $\frac{1}{2}$ in. distal to ligature ; note that no bleeding occurs from stump and return to abdomen. Sac is now carefully isolated from cord or round ligament, the usual place to begin this being near the internal ring. Isolate neck of sac thoroughly, draw down and if narrow ligature with catgut; if broad, pass double catgut suture transversely through middle and tie each side separately, interlocking ligatures. Cut sac off $\frac{1}{2}$ in. distal to ligature and allow stump to slip back into abdomen. Pick up forceps on lower side of external oblique aponeurosis, make this taut, and expose Poupart's ligament by dissection with point of closed scissors (fig. 54). Define conjoined tendon. Insert two or three (according to size of opening) sutures of stout catgut or silk, taking good hold of conjoined tendon and upper surface of Poupart's ligament, and tie sufficiently firmly to make these two structures lie together snugly. The upper of these sutures obliterates the internal ring; the lower is

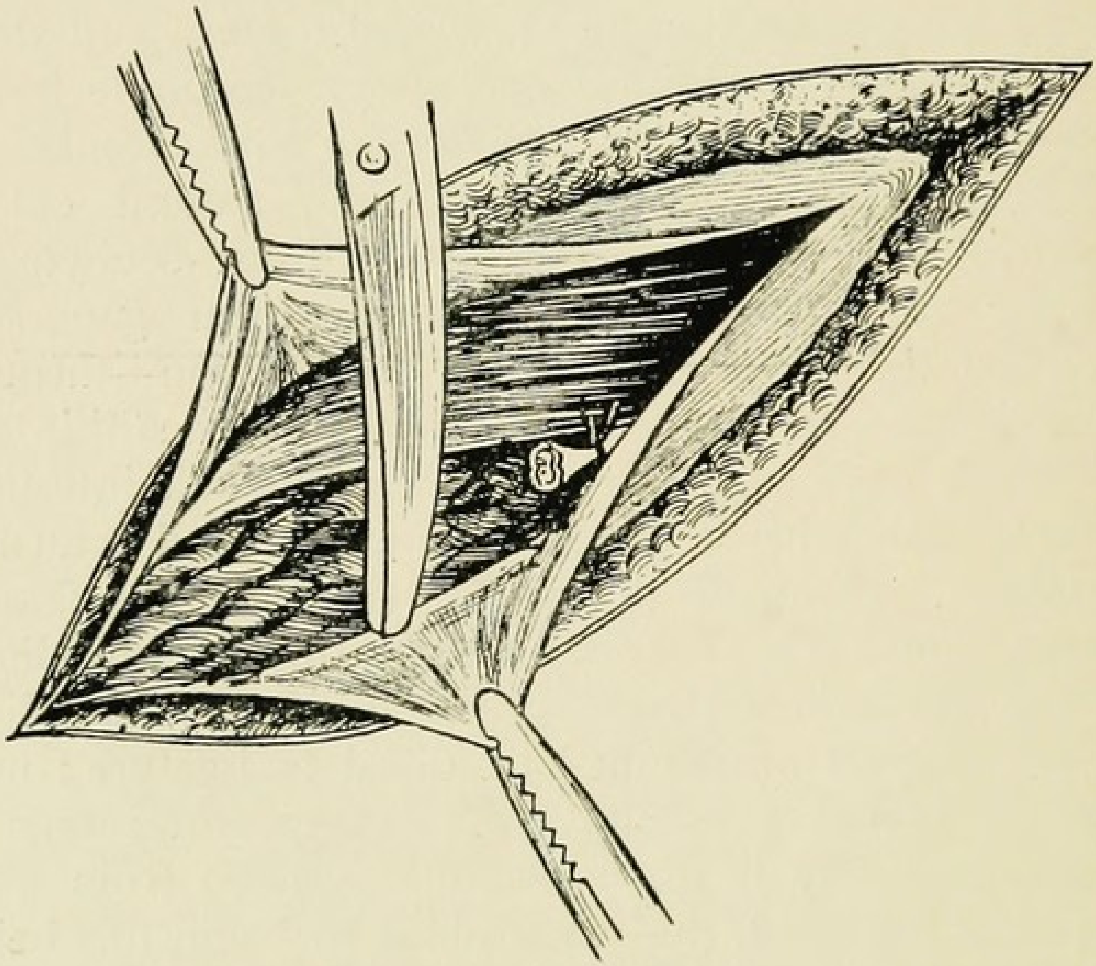

FIG. 54.—Exposure of Poupart's ligament and conjoined tendon. The ligatured neck of the sac is shown, but it should have retracted out of sight into the abdomen.

placed so as to leave room for the cord to emerge internal to it. Upper and lower edges of external oblique aponeurosis are now made to overlap, the lower one undermost, and are fixed in position by mattress sutures of catgut. In passing sutures near Poupart's ligament care must be taken to avoid injury to femoral vessels. Suture subcutaneous tissues with fine catgut and insert subcuticular suture to close external wound.

Dressings.—Dressings are applied with firm compression over wound and removed in twenty-four hours when tendency to effusion will have subsided. Wound then covered with mild antiseptic powder, *e.g.*, boric acid. Patient kept in bed for three weeks, and for following three weeks must do no hard work. (See also p. 310.)

If condition of bowel be very doubtful, but chances be in favour of its recovery, it may be considered safer to return loop to abdomen and insert cigarette drain to just within abdomen. The loop when returned tends apparently to remain opposite to the opening. If perforation occurs later, discharge will be conducted externally. Tube may be removed on third to fifth day if bowels have moved satisfactorily.

If gangrene undoubtedly present, neck of sac should be opened widely. Bowel pulled well down till several inches of healthy gut are exposed on both sides of affected part. Pass, on each side of gangrenous portion and distant therefrom 3 to 4 in., a thick silk ligature through mesentery close to gut, avoiding vessels, and tie round gut sufficiently tightly just to occlude lumen. These ligatures may be used instead of bowel clamps. Select site of division of bowel on both sides of gangrene at least 1 in. distal therefrom and clamp mesentery between these points with artery forceps. Pack gauze strips closely on both sides of mesentery, inserting ends into neck of sac. Cut mesentery distal to forceps. Gangrenous bowel is then removed and healthy ends approximated by suture or mechanical appliances such as Murphy's button, according to technique described in section dealing with intestinal surgery. Remove ligatures occluding bowel, ligature mesentery and approximate edges by catgut or fine silk suture, using rounded needle. Remove gauze, place swabs on either side of mesentery in neck of sac, wash exposed parts thoroughly, remove swabs and return bowel to abdomen. *If condition of patient be very serious*, an artificial anus may be made. Afferent and efferent bowel are occluded by assistants' fingers or ligature as described, gauze strips packed around parts, and after rapid removal of gangrenous portion and clamping of mesentery, a thick rubber drainage tube is inserted into each end of the bowel. Bowel is made to lie snugly round the tubes by purse-string suture of silk or catgut. Direct ends of tubes into basin to receive fæces, remove occluding ligatures, and return excess of bowel, after washing, into abdomen. Fix bowel and mesentery in the wound by interrupted sutures. Wash thoroughly with saline solution, stitch up excess of wound and apply dressings. Tubes should be fixed to bandage by safety pins pushed through lumen and are connected with receptacle at side of bed. If recovery ensues, a surgeon should treat the case as soon as condition of patient permits, as the drainage of the small intestine means severe drain upon the patient's nutrition and strength.

Remarks.—Local anæsthesia is easily carried out as it is possible to inject plentifully a dilute solution of the anæsthetic round the tumour. The neck of the sac may be treated after the incision is made and the sac freed. Injections should be made round the neck of the sac as closely as possible.

There is sometimes difficulty in reducing the bowel, owing to the bulging of the sac immediately distal to its neck, the difficulty is overcome by attaching forceps on opposite sides of the sac and making traction on them to obliterate this bulging, when the bowel is gently squeezed back into the abdomen.

The above treatment of the cord (Fowler's) is the simplest and easiest for those who have not much practice in operating; in fact, many experienced operators prefer this plan, and the results are as satisfactory as those of other methods, *e.g.*, Bassini's.

The essential features of the operation are: strict asepsis and hæmostasis, careful coaptation of muscles, and, above all, thorough obliteration of the sac and its neck, so that no funnel-shaped pouch of peritoneum is left.

Strangulated Femoral Hernia.

Anæsthesia.—Same as for inguinal hernia.

Instruments.—Same as for inguinal hernia.

Technique.—Prepare skin as for inguinal hernia. Vertical incision over middle of swelling 3 in. long, deepen until sac is reached; with finger quickly separate sac to its neck. Ragged portions of cribriform fascia, &c., are best removed. Open sac and treat contents and neck of sac as in inguinal hernia. Avoid, if possible, cutting through Poupart's ligament. Reduce contents, isolate neck of sac externally by blunt instruments, pull down, ligature high up and cut off $\frac{1}{2}$ in. distal to ligature; the stump slips into abdomen. With finger in opening guard femoral vein by pushing outwards, and pass mattress suture (silkworm gut) first through Poupart's ligament from before backwards, take good hold of pectineal fascia and muscle, then back through the ligament from behind forwards and tie firmly; tie bleeding vessels; suture skin; apply firm compression for twenty-four hours. Thereafter treat as in inguinal hernia. (See also p. 310.)

Remarks.—In separating the neck of the sac at the inner side, care must be taken to avoid injury to the bladder, which is fairly frequently present there. There is but little danger of hæmorrhage from an abnormal obturator artery, if the constricting neck be freed by cutting outside of sac, or a hernia knife with dull edge be used. The danger of wounding the femoral vein need be mentioned only to be guarded against. Other remarks found under inguinal herniotomy apply equally to femoral herniotomy.

TRACHEOTOMY.

Anæsthesia. — In children a general anæsthetic (chloroform) is practically compulsory. In adults a local anæsthetic may be preferable. If patient be unconscious no anæsthetic is necessary.

Instruments.—Scalpel; blunt-pointed scissors, curved or flat; six artery forcipes; two dissection forcipes; two sharp hooks; tracheotomy tube which will fit the trachea snugly, with tapes attached; long feathers of hen or pheasant cleansed with antiseptic, and lying in a solution of bicarbonate of soda; catgut ligatures; strong silk or silkworm gut sutures.

Technique.—High operation, *i.e.*, above isthmus of thyroid. Patient on back on firm, narrow table; flat pillow below shoulder and neck; anæsthetist or assistant steadies head in middle line. Palpate landmarks from above down, viz., hyoid bone, pomum Adami, cricoid cartilage. Incision through skin $1\frac{1}{2}$ in. long, in mid-line, down to deep fascia, upper third being over cricoid cartilage. A transverse vein may require to be secured by forceps. Fix cricoid by inserting sharp hook beneath lower border and pulling gently upwards; assistant or anæsthetist holds this. Divide cricotracheal membrane vertically. Cut or tear with two dissection forceps down to trachea, keeping exactly in mid-line. Thyroid isthmus, if visible, should be displaced downwards by finger or blunt-pointed curved scissors. If isthmus incised and arteries at upper border bleed, these must be clamped. Lay bare upper three rings of trachea; cut these rings with scalpel from below up, exactly in mid-line, taking care not to plunge scalpel into posterior wall of trachea. Before withdrawing scalpel, insert sharp hook into slit in trachea; retract one side; release cricoid and retract other side of trachea with sharp hook; hooks now handed to assistant or anæsthetist, who keeps aperture in trachea sufficiently patent. Anxiety as to success of operation now usually over; patient indulges in sputtering coughs and deep inspirations. Prevent dissemination of membrane or mucus by swab held lightly over tracheal opening; wipe at end of each expiration. Membrane adherent to trachea below opening may be loosened by carefully inserting feather, which is then gently rotated and withdrawn. If membrane sucked or pushed down trachea, sudden compression of chest will usually bring it up. Period of peaceful apnœa usually succeeds the respiratory storm which occurs on opening trachea, and although respirations may be suspended the pulse is felt. This relieves anxiety.

Insert a loop of strong silkworm gut or silk on each side of tracheal wound, taking good hold of trachea and superficial structures; tie loops long; use these as tracheal dilators in place of hooks, which are therefore removed. If breathing be regular and trachea clear, tube is now easily inserted and secured by tapes tied round neck (fig. 55). Close excess of wound by suture above and below tube. Usually unnecessary to tie any vessels.

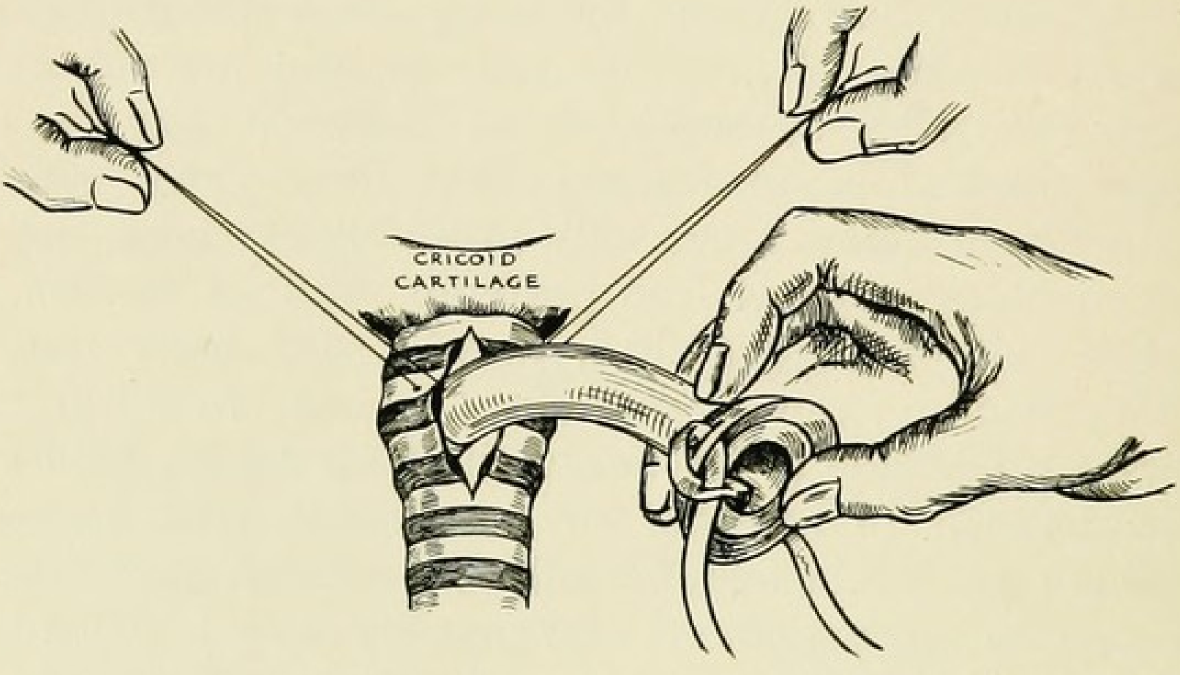

FIG. 55.—Introduction of tracheotomy tube. The sides of the tracheal opening are held apart by loops which obviate the use of a special dilator.

Dressing.—Fine gauze, teased, and slightly moistened with warm, mild, antiseptic solution, laid lightly over the tube.

If room be kept thoroughly warm steam tents are unnecessary, but steam kettle is advisable in order to keep atmosphere moist and prevent formation of crusts.

Remarks.—Tracheal loops have an immense advantage over the old tracheal dilator. They are usually inserted when the sharp hooks are *in situ*. The insertion of the tube is rendered easier by their use. During after-treatment the nurse in attendance has a feeling of greater confidence in that should any serious difficulty with the tube occur, it may be at once removed after cutting the tapes, and the trachea be held open, if necessary, until help arrives.

COMPOUND FRACTURES.

Such injuries should be attended to as speedily as possible. Within twelve hours of the injury by suitable treatment an aseptic wound can be procured with comparative certainty. After twelve hours the difficulty of removing sepsis increases hourly. This is especially important in the case of head injuries.

Anæsthesia. — General for head injuries unless patient be already unconscious. Local (Bier's) for the extremities. (See "Amputations.")

Instruments.—Scalpel; scissors; artery and dissection forcipes; wound hooks or retractors; hammer and chisel; saw; gouge forceps; elevator; trephine ($\frac{1}{2}$ in. to $\frac{3}{4}$ in.); needles; ligature and suture material.

Technique.—Shave the part and a considerable area round it. Remove all visible foreign bodies. Scrub both wound and surrounding skin with sterile nail-brush, soap and water, changing all these frequently. Dry the part, and disinfect hands between each relay. This may be done by operator and assistant in turn. Dry with sterile towel; rub thoroughly with swabs dipped in fat solvent (ether, spirit of turpentine), and surround area of operation with sterile towels. Excise

$\frac{1}{4}$ in. of edge of wound in skin, subcutaneous tissue and fascia. Enlarge wound, if necessary, for subsequent manipulation. Clip away ragged and soiled bits of muscle. Remove loose pieces of bone which are soiled or entirely denuded of periosteum. Project, if possible, ends of main fragment from the wound (easily done if bone has previously protruded), trim off presumably soiled end with chisel or saw. Clear away clot, wash out thoroughly with normal saline or dilute peroxide of hydrogen solution; the latter tends to check oozing. Approximate ends of bone; stitch ruptured muscles with a few catgut sutures; insert split rubber tube; if possible approximate deep fascia with catgut, and stitch skin.

Dressing.—Mildly antiseptic dressings such as cyanide gauze, boric powder with plain gauze, or gauze wrung out of weak antiseptic solution are advisable; absorbent wool, firm bandage, and suitable splint.

There is no great objection to encircling with plaster of Paris bandages in such cases, as free exit for exudate is provided, thereby preventing swelling. The site of tube may be marked on the plaster. If no evidence of sepsis in two to three days, window may be cut in plaster and tube removed, without disturbing the rest of the dressing.

Cranial Injuries.

Employ similar technique in the main—pp. 331-332. Enlarge wound to make certain of presence or extent of fracture. If fracture depressed and fragments immovable, apply small $\frac{1}{2}$-in. trephine to edge of sound bone and remove semi-circular piece (fig. 56). Insert elevator cautiously through opening and try to elevate depressed part; if unsuccessful, nibble away edge of sound bone adjacent to depressed fragment with gouge forceps till bone can be raised. Remove all loose fragments unless they are unsoiled and connected with sound bone by pericranium. All soiled fragments and edges of unbroken bone must be removed, the latter by gouge forceps. All foreign material, pieces of metal, stone, hair, &c., must be carefully removed.

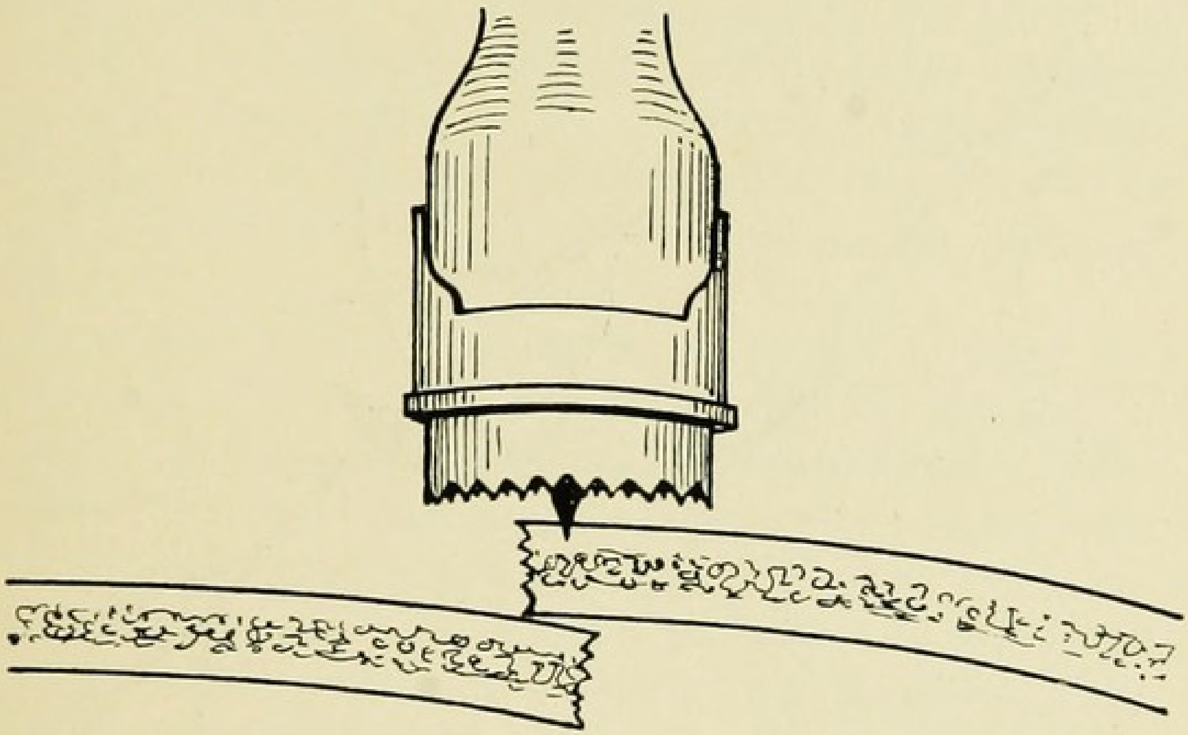

FIG. 56.—Application of trephine in treatment of depressed fracture.

If dura or brain be wounded, snip away lacerated pieces. If meningeal vessel be bleeding, underrun with rounded needle and fine silk as in fig. 57; wash with sterile saline or weak peroxide of hydrogen solution. Adjust edges of wound in dura by suture if possible. Insert gauze wick, bringing it out at angle of wound and approximate edges of scalp, except where drain emerges.

AMPUTATIONS.

Remarks.—One must remember that under modern technique, where asepsis can be assured, the indications for amputation in injuries have become more limited. It is often wise, even though much destruction of tissue has occurred, to give the limb a chance after thorough cleansing. Such a policy is often successful in the case of fingers, even although separation be

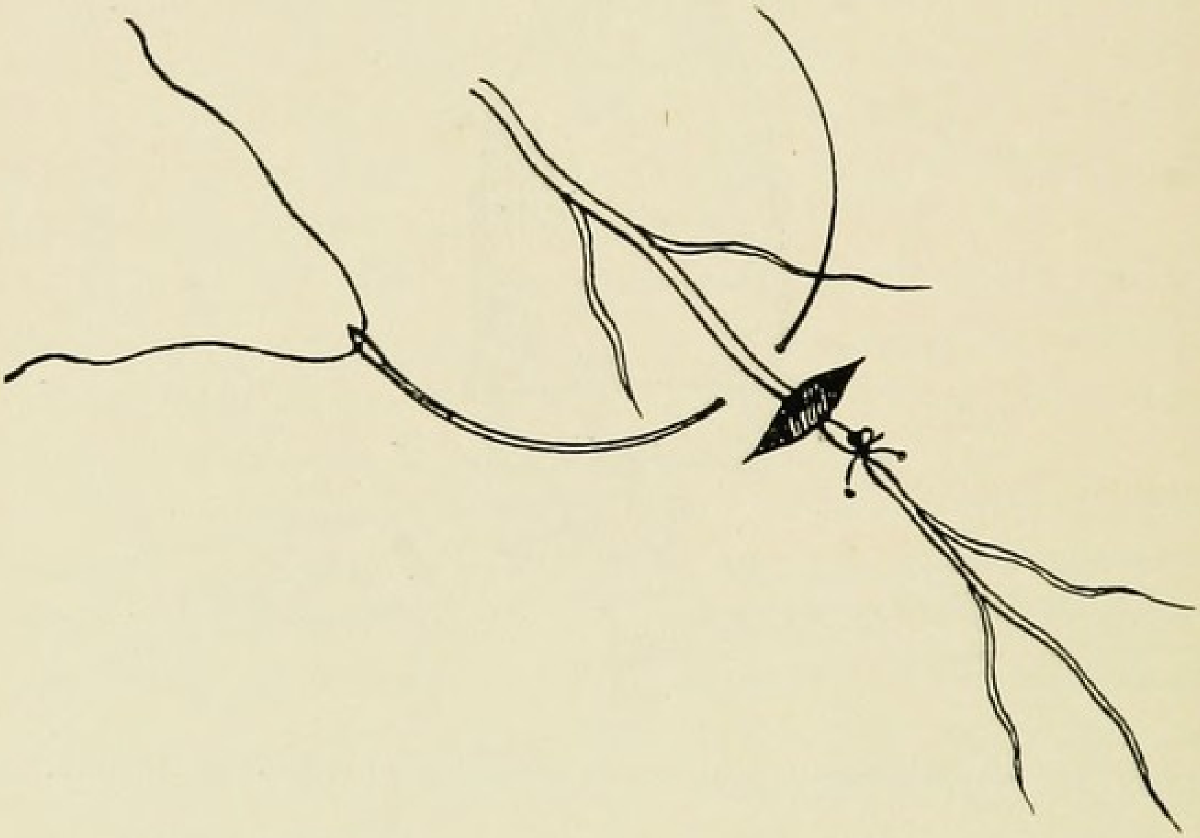

FIG. 57.—Ligature of meningeal vessel by under-running.

almost complete. In coming to a decision, in the case of major amputations especially, one must consider (*a*) the severity of the injury, (*b*) the time elapsed between the accident and the commencement of treatment (the shorter the better), (*c*) the presence or absence of sepsis, (*d*) the occupation of the patient, (*e*) the probability of successful restoration of function, (*f*) and the length of time required for this.

Owing to the possible presence of infective organisms in the wound, it is advisable not to use foreign material such as wires, staples, metal plates, &c., for fixing broken fragments of bone. If such be absolutely necessary, a smooth nail, inserted through suitably placed drill-holes in the bone, is usually sufficient. It should be removed within a week. If sepsis be already present it is advisable merely to clear the wound of lacerated or necrotic tissue, foreign bodies, &c., and drain efficiently. Do not interfere much with the bone because osteomyelitis may be set up easily. Malunion may be rectified when the parts are healed.

Anæsthesia.—For amputation at or below lower end of humerus or femur, Bier's intravenous method of producing local anæsthesia is amply sufficient. For fingers or toes, infiltration anæsthesia round base. For others a general anæsthetic is preferable.

Instruments.—Large scalpel ; scissors, blunt-pointed, curved or flat ; dissection and artery forcipes ; tourniquet—elastic cord or rubber bandage ; saw ; bone forceps ; retractors ; sharp hooks ; ligature and suture material ; drainage tube ; novocain and large syringe.

Technique.—The modified circular or coat sleeve method is applicable to practically all amputations at or below the proximal joint of either extremity. In amputations for injuries no definite method can be laid down ; advantage should be taken of all available healthy skin for making flaps so that, as a rule, the limb is left as long as possible. Amputation through the forearm may be taken as an example. Disinfect skin of entire upper extremity, wrap wrist and hand in sterile towel, elevate extremity to empty of blood; apply tourniquet (rubber bandage) on upper arm. Arrange sterilized sheets or towels, fastening them around arm immediately below tourniquet. With a few drops of local anæsthetic, isolate a vein at bend of elbow; into it inject with suitable syringe 30 to 40 c.cm. of $\frac{1}{4}$ to $\frac{1}{2}$ per cent. novocaine solution; more is required for the lower extremity. If amputation is done for injury, a constricting band must be placed at or immediately below site selected for amputation—in order to prevent novocaine solution escaping from veins. After three to five minutes remove lower constricting band and make incision round forearm; reflect skin and subcutaneous tissue for $1\frac{1}{2}$ in. all round, making vertical incision on ulnar side $1\frac{1}{2}$ in. long, and short notch on radial side. Divide deep fascia, muscles and interosseous membrane transversely, free bones upwards for another $\frac{1}{2}$ in. or thereby, retract muscles and skin flap, divide bones transversely with saw, holding forearm midway between pro- and supination. Cut nerves short and square. In old or debilitated subjects carefully remove aponeurosis and stumps of tendons as they are apt to slough. Clamp main vessels; remove tourniquet; secure bleeding points and apply ligatures. Stitch flap transversely. Insert drainage tube at side, wash skin, and apply dressings.

Remarks.—In amputations of the fingers it is particularly desirable to maintain the stump as long as possible. To preserve movement, the ends of the flexor and extensor tendons may be sutured across the stump of the phalanx.

In amputations for septic mischief, if the division be not made absolutely clear of the disease, the flaps should be left open for a few days, the interior of the wound being packed with gauze. Sutures (unabsorbable) are inserted, but left long and knotted at their ends. They may be tied when the gauze is removed if there be no inflammation in the stump.

CONTUSED, INCISED AND LACERATED WOUNDS.

Anæsthesia.—In cases of abrasion, lacerated or incised wounds an anæsthetic is advisable. It usually suffices in abrasions merely to soak the part with a fairly strong local anæsthetic for a few minutes. This may be sufficient also in certain limited lacerated or incised wounds, but, if extensive, the "infiltration" method, Bier's method or a general anæsthetic is more suitable.

Technique.—In all these forms of wounds thorough disinfection of the wound and surrounding skin is necessary to prevent sepsis. In contusions without wound of skin, if, after thorough disinfection and firm compression, the effused blood does not tend to become absorbed within a few days, it may be either aspirated or let out through a small incision. In either case compression of the part must follow to prevent reaccumulation of fluid; if this occurs insert a small drain.

In incised or lacerated wounds, thoroughly scrub wound and surrounding skin with sterile nail-brush, soap and water, beginning at the wound and working centrifugally. Soap-suds are washed or dried off and process repeated by assistant, if present, with fresh nail-brush, soap and water. Operator meanwhile cleanses his hands. In extensive injuries, when the skin is very dirty, this process should be repeated several times. The part is finally dried with sterile towel, wound opened, washed out with fat solvent (ether, spirit, turpentine, &c.), swab held within it while surrounding skin likewise thoroughly wiped. Surround area of operation with sterile towels. If wound be clean cut, it may be safe now to wash it out with sterile salt solution and stitch it up. If, however, edges, whether of skin or subcutaneous tissues, be soiled or lacerated, it is safer to excise a narrow margin of these and then to suture the wound after controlling hæmorrhage and washing out with sterile salt solution.

In deep wounds with much laceration of tissues, and especially if compression cannot be satisfactorily applied, it is better to insert for a day or two a split rubber tube reaching to the depth.

PUNCTURED WOUNDS OF CHEST AND ABDOMEN.

A.—Of Chest.

None but a specialist need attempt to deal with wounds of the heart. Practically the only punctured wounds with which one may deal, where limited assistance is at disposal, are those producing hæmorrhage from the parietal vessels, viz., intercostals and internal mammary. Evidence of profuse hæmorrhage in the pleural cavity and, still more, severe external hæmorrhage form clear indications for active interference.

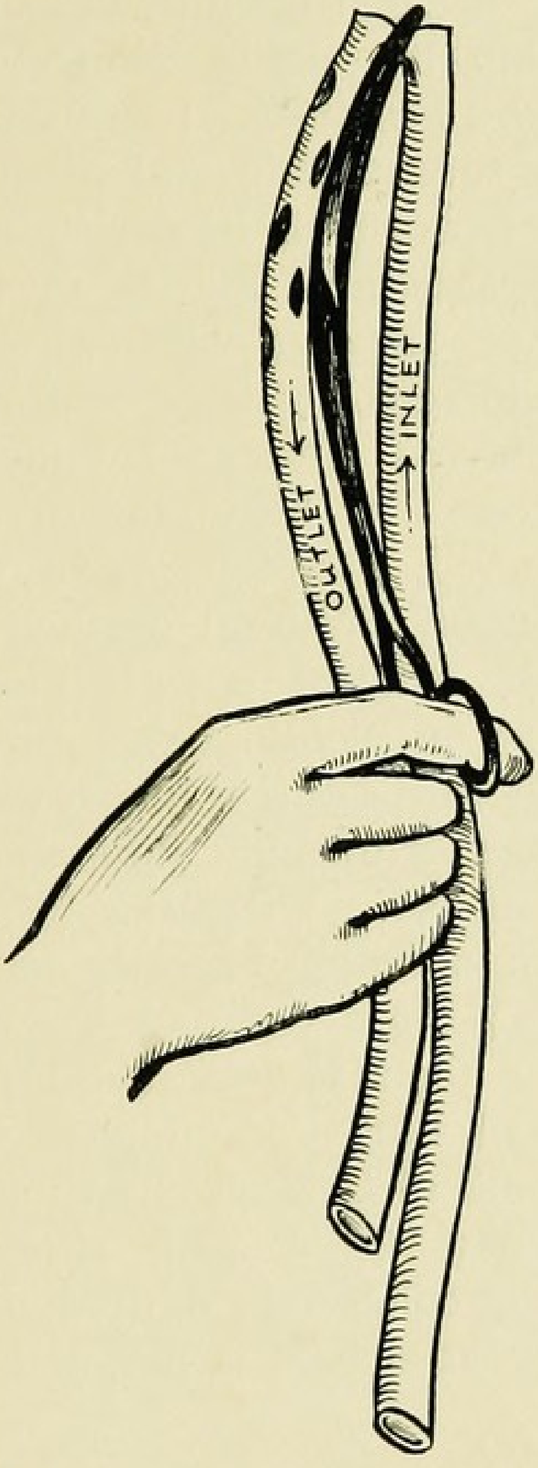

FIG. 58.—Arrangement for flushing.

Anæsthesia.—Local, if wound small or respiration seriously interfered with, otherwise general.

Instruments.—Scalpel ; scissors, blunt-pointed ; dissection and artery forcipes; blunt hooks; raspatory; bone forcipes; curved needles—rounded and sharp edged; drainage tubing; ligature and suture material.

Technique.—Skin thoroughly disinfected as described under "Compound Fractures"; wound enlarged horizontally, after excision of skin and subcutaneous tissue surrounding it; periosteum or perichondrium incised for $1\frac{1}{2}$ in., corresponding to site of puncture, and elevated off rib or cartilage with raspatory. Rib excised with bone forceps, cartilage removed with knife, taking care to avoid injury of underlying pleura. Bleeding vessel can now be underrun on both sides of wound by curved, rounded needle, threaded with silk or strong catgut. Wound drained with tube or gauze, and excess stitched up. If pleura wounded, and blood and air in pleural cavity, attempt may be made to wash out with saline solution through double-channelled catheter or through tube and long forceps arranged as in fig. 58. Thereafter fill pleural cavity with salt solution, avoiding excessive pressure; stitch wound in pleura; close external wound, and apply pressure over it; then aspirate fluid from chest to cause expansion of lung. If lung be wounded it is better to leave bulk of fluid in chest, otherwise bleeding from lung may begin again although probably stopped when lung collapsed; the remaining fluid will gradually become absorbed, if not, it may be drawn off later.

B.—Of Abdomen.

If there is evident puncture of intestines or other hollow viscera, especially if from gunshot injury, unless severe hæmorrhage is apparent, place the patient in Fowler's position, and await surgical help. If the abdominal parietes be alone wounded by stab or laceration, disinfect skin as already described, excise edges of wound in skin, subcutaneous tissue and muscle, as deep as the puncture is found to penetrate, retracting each layer in succession. If peritoneum be opened, excise cut edges, enlarge wound slightly, sponge exposed bowel lightly with saline solution, looking carefully for presence of bowel contents or escape of gas. If bowel punctured only on one side, it is fairly certain that no other coils are wounded. Close wound in bowel by passing purse-string suture round it through outer coats; wipe soiled bowel carefully with swabs and sterile saline solution. If there be no extensive soiling of peritoneum, close abdominal wound in layers with catgut, and place patient in Fowler's position. If there be extensive soiling, it may be advisable to drain through wound of injury, and also make an incision over the pubis in mid-line, insert thick cigarette drain to bottom of pelvis, and place patient in Fowler's position.

If signs of internal hæmorrhage occur: (*a*) If wound near the flank, enlarge it sufficiently (4 in. to 5 in.) to allow search for bleeding vessel. (*b*) If wound nearer middle of abdomen, make 4 in. to 5 in. incision in mid-line, explore for bleeding point, catch with forceps and ligature with fine silk. Bleeding from solid viscera may be controlled by packing with gauze.

Remarks.—The treatment of such cases is often of extreme difficulty, and should be undertaken by an unpractised hand only in cases of the *direst* necessity.

EXCISION OF LOCALIZED SUPERFICIAL TUMOURS, e.g., SEBACEOUS CYSTS, LIPOMATA, &c.

Anæsthesia. — Usually local infiltration. Bier's method may be used in the extremities, if the tumour be fairly large and difficult to surround with anæsthetic solution.

Instruments. — Scalpel ; scissors, blunt-pointed, curved ; dissection and artery forcipes ; blunt wound hooks ; needles ; ligature and suture material.

Technique.—Usual disinfection of skin overlying and surrounding tumour. Isolate field of operation by aseptic towels. Longitudinal or elliptical incision over whole length of tumour. Cut through subcutaneous tissue till capsule reached. Retract. Shell out tumour with finger or closed blunt-pointed scissors, avoiding nerves, catching, cutting, and ligaturing vessels when necessary. Draw together subcutaneous tissues with fine catgut suture to prevent formation of "dead" spaces, and insert, preferably, subcuticular suture to avoid unsightly scar. Apply dressings with firm compression.

In scalp, subcutaneous suture is unnecessary, so also is subcuticular suture, except in bald people.

BURNS AND SCALDS.

What has been said of other wounds applies also to burns. Asepsis may practically be assured if proper treatment be initiated within twelve hours ; every hour thereafter renders this less probable. One must remember that, in and on the skin, organisms abound. If these be not removed, they multiply readily in the effused serum and half-dead tissue due to the burn. The consequent inflammation brings about necrosis in the damaged area, hence it is that burns, apparently superficial at first, become, in the language of Dupuytren's classification, "two degrees" more severe. Dressing with oils or ointments, without previous disinfection of the application and of the part burnt, fails to procure the necessary asepticity. Nature's process is to heal under a scab. Healing occurs quickest and best when the scab is aseptic.

A satisfactory method of dealing with such injuries is :—

Anæsthesia.—General.

Technique.—Scrub the affected and adjacent parts thoroughly first with soap and water, several relays (see "Compound Fractures"); then with fat-solvents, plus antiseptic. Dry with sterile towel. Dust profusely with a powder consisting of equal parts of boric acid and carbonate of bismuth.

In bed, place cages round the affected part to prevent displacement of powder. No other dressing is applied. Place mackintosh to prevent soiling of bedclothes. Wipe away effused serum which trickles over sound skin. Apply more powder when necessary. A thick, dirty-looking scab forms, which, however, has slightly antiseptic action. Beneath it, the parts are bathed in Nature's dressing—serum.

If scab smells badly or sloughs likely to form, remove scab every seven to ten days, until fœtor subsides or sloughs separate; dust on fresh powder after each removal; otherwise leave parts undisturbed even for weeks if burn be extensive.

A thin, soft, pliable, vascular scar forms, which does not easily break down, in striking contrast to the thick, hard, unyielding, brittle scar obtained by the usual treatment of repeated dressings and application of antiseptics. Exceptions occur at the flexures of joints where movement and consequent interference with healing occurs; here the process takes longer, and the scar is liable to be thick and unyielding. The limbs should therefore be kept extended and at rest as much as possible, except for movement once daily to prevent intra-articular adhesions. In six to ten weeks areas measuring 6 in. by 12 in., completely denuded of skin, may be completely healed by this method, without any adventitious aid, such as skin-grafting.

The *picric acid* treatment has become popular of recent years. It consists in the application, after thorough disinfection, of gauze soaked in a ½ per cent. to 1 per cent. solution of picric acid, or of a 1 per cent. ointment:—

℞	Ac. picric	ʒi. ss.
	Alcohol absolut.	℥iii.
	Aq. destillat.	℥xl.

Here, again, the dressing should be left *in situ* as long as possible. For other methods of treatment see article on "Burns."

Remarks. — In severe burning injuries the most serious condition requiring immediate attention is "shock." As in shock from other causes, infusion of saline solution is one of the most reliable remedies; it should be given preferably by way of a vein, either before or during the general anæsthesia.

EXPLORATORY PUNCTURE AND PARACENTESIS.

For this the skin cannot be too thoroughly cleansed. Owing to the danger of carrying infection to the depths when a large needle or trocar is used, it is well to make, at the site of puncture, a small stab with a scalpel, wipe the opening thus produced and introduce the instrument carefully between the edges of skin. In a sensitive patient the skin should be anæsthetized previously, by freezing or by infiltration.

Exploratory Puncture.

Instruments.—Exploring needle 3 in. to 4 in. long, which screws or fixes by catch to a syringe fitted with a glass barrel—all sterilizable.

A.—Of Chest.

Sites.—(1) Seventh to ninth intercostal space in mid-axillary line, or (2) middle of area where localized fluid is suspected.

Technique. — Pull skin upwards or downwards slightly; mark upper border of rib, immediately above this plunge in needle smartly, preventing it going deeper than 1 in. to 1½ in. (before insertion the needle must be attached to the syringe with plunger pushed down). Gently withdraw plunger quarter length of barrel; if no fluid appears in barrel, pull needle out slightly and re-insert in different direction, withdraw plunger another quarter, and if still no fluid repeat the manœuvre.

Remove needle smartly, supporting skin with finger, allow skin to slip into normal position; a valvular opening is thus made. Cover puncture with small piece of adhesive plaster.

B.—Of Pericardium.

Site.—Third and fourth interchondral space, two fingers' breadth from left margin of sternum.

Technique.—As in A.

C.—Of Joints.

Site. — Where synovial membrane comes nearest surface, and vessels and nerves can be avoided :—

(1) Knee, 1 to $1\frac{1}{2}$ in. above patella to inner side of the rectus tendon.

(2) Ankle, at either side of extensor tendons where bulging most prominent.

(3) Elbow, either side of triceps tendon where bulging most prominent ; avoid ulnar nerve on inner side.

Technique.—Grasp joint gently but firmly, in order to increase bulging at site of puncture ; needle then introduced smartly ; avoid striking bone ; proceed as in A.

Remarks.—If fluid removed be purulent, the case should be seen by a surgeon as soon as possible.

D.—Lumbar Puncture.

Instruments.—Scalpel ; special hollow needle 4 in. long with short point ; sterilized test-tube and cork.

Site.—Any of the lumbar interlaminar spaces from the second to the fourth, preferably second or third. A line between highest points of iliac crests passes across fourth lumbar spine.

Technique.—Place patient in sitting posture, with back well flexed in order to open up interlaminar spaces. Through small stab wound in mid-line, or slightly to one side, at site selected, introduce needle (detached from syringe), directed slightly upwards to reach interlaminar space. Push steadily onwards till cerebrospinal fluid flows (usually 2 in. to $2\frac{1}{2}$ in.; 4 to 6 cm.) Increased resistance is felt as needle passes through the ligamentum subflavum; it is apt to plunge when this is penetrated. Have sterile test-tube handy to catch fluid, which drops more or less freely from needle. One or two drachms are amply sufficient for diagnostic purposes. Close test-tube with sterilized cork; remove needle and apply plaster as in A.

Difficulties.—(1) The needle may impinge on bone; withdraw 1 in. and reinsert at slightly higher or lower level. (2) The needle may fill with blood, withdraw altogether and re-insert after cleansing by syringing through it sterile water, or by passing a stilette.

PARACENTESIS.

It is safer in all cases to make preliminary stab wound through skin at site of puncture. (See above.)

Instruments.—Aspirator (Potain's); needles and trocars of various sizes; quart bottle with neck to suit cork of apparatus. The needles and trocar apparatus must be sterilized, and the working of the whole apparatus tested each time before using. Some prefer to use, instead of the aspirator, a trocar and cannula with side tube attached, through which the fluid runs after withdrawal of trocar (fig. 59).

A.—Paracentesis Thoracis.

Sites.—Needle introduced at level sufficient to clear arch of diaphragm: (1) and (2) as in exploratory puncture; (3) posteriorly in scapular line two spaces above lowest limit of healthy breathing on opposite side.

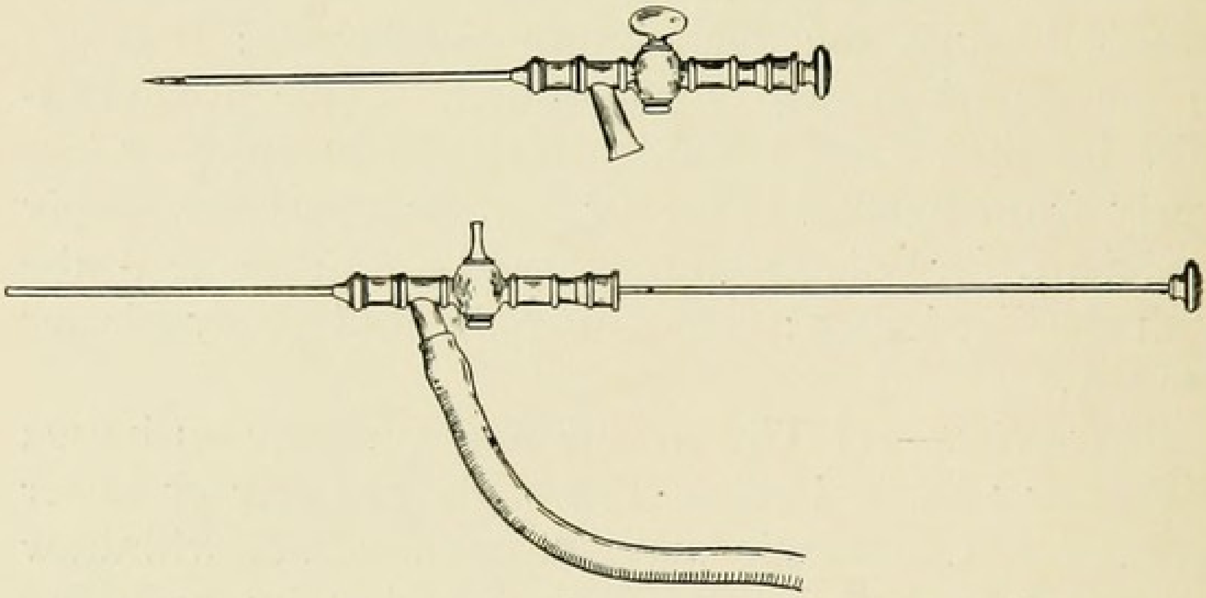

FIG. 59.—Trocar and cannula with side tube attachment.

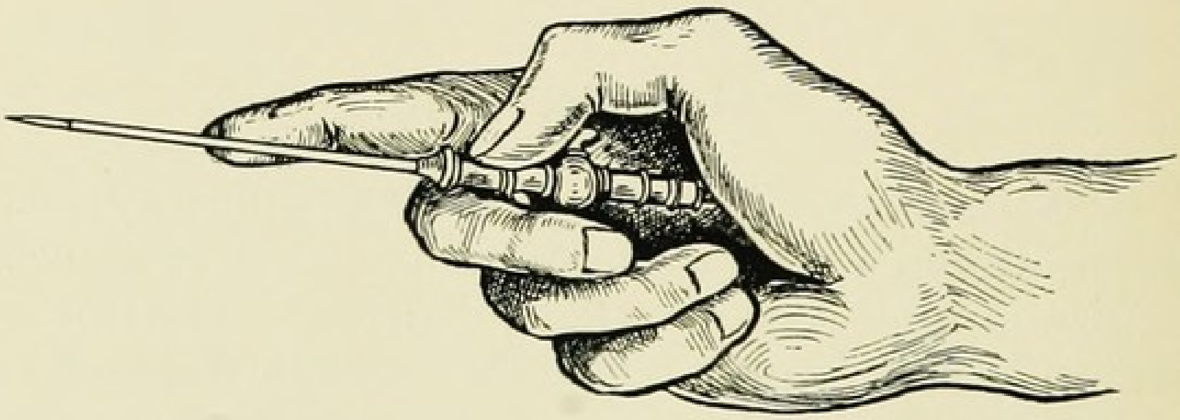

FIG. 60.—Method of holding trocar and cannula.

Technique. — Patient in semi-recumbent position. Introduce trocar and cannula as in exploratory puncture. A sharp push is required in order to penetrate the pleura, which may be thickened. By finger, guard the instrument from penetrating too deeply (fig. 60); withdraw trocar and turn stopcocks. When fluid runs freely cannula should be pointed obliquely upwards to prevent diaphragm or expanding lung blocking its opening. Do not remove fluid too rapidly. Screw off flow occasionally to allow heart and lungs to accommodate themselves to altered circulation, otherwise patient may become faint, or actually collapse, may expectorate frothy material, or hæmorrhage may occur causing the sputum to be blood-stained. At the same time the bottle may be emptied, if necessary. It is rarely necessary to remove the fluid completely. If intrapleural tension be sufficiently lowered, absorption of remaining fluid is usually ensured. Finish as in exploratory puncture.

B.—Paracentesis Abdominis, for Ascites.

Sites.—(1) In middle line, below point midway between symphysis pubis and umbilicus. (*N.B.*, bladder must be empty.)

(2) Midway between umbilicus and anterior superior spine—more danger of wounding parietal vessels; if this occurs cut down and ligature.

Instruments.—Aspirator; syphon trocar and cannula (trocar and cannula crowquil in size); Southey's tubes.

Technique.—Cleanse skin very thoroughly as intertrigo frequently present. Patient propped up in half-sitting posture, so that intestines float upwards. Binder or towel, with split ends, placed under patient's back. Over site of puncture, preferably through stab wound of skin, plunge instrument—guarded as in (fig. 60)—smartly through abdominal wall; pull trocar back;

turn stopcock, and aspirate slowly. Towards the end of the process the intra-abdominal pressure may be kept up by applying traction to the crossed ends of the binder. The point of the cannula may have to be moved gently in different directions, especially downwards, as it may become occluded by the descending intestine.

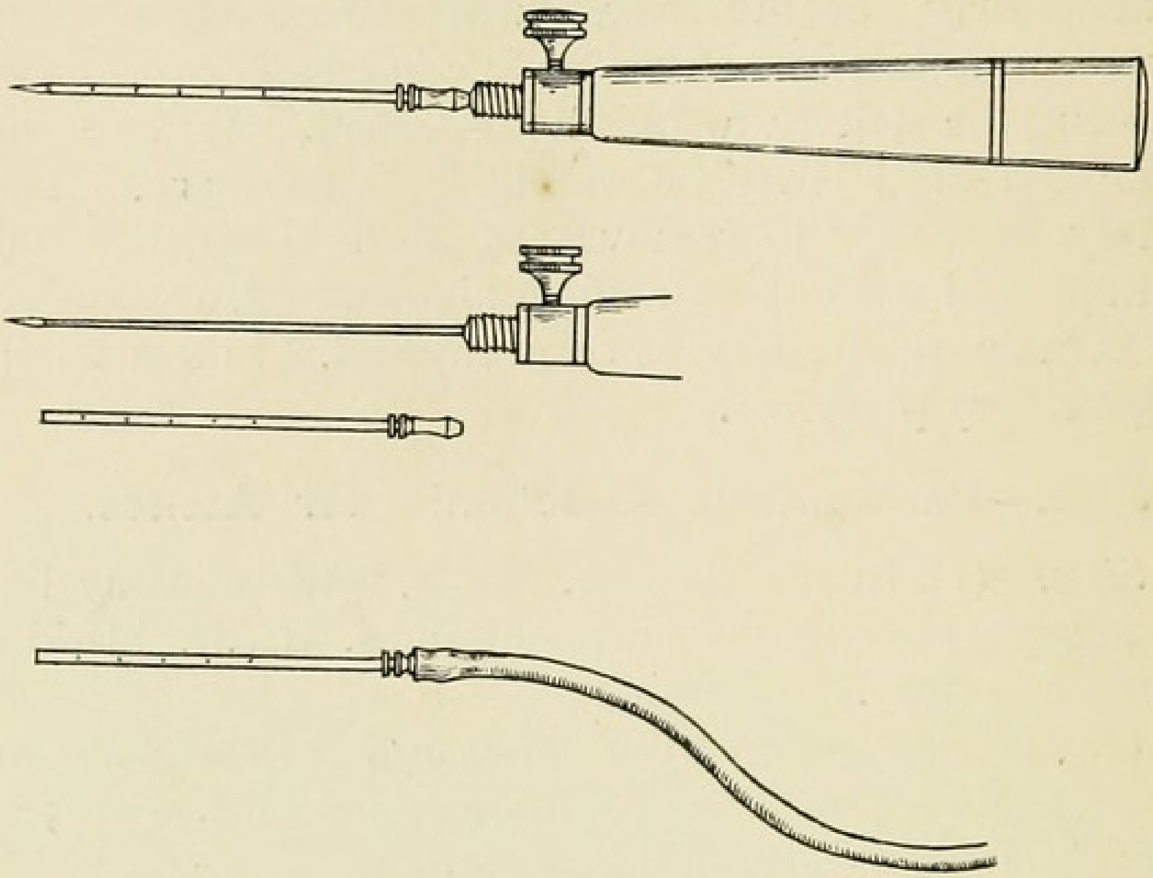

FIG. 61.—Southey's tube.

When no more fluid can be withdrawn the cannula is removed smartly, and the puncture sealed by adhesive plaster. The binder should now be firmly fixed round the abdomen, because the patient may become faint from want of support to the intra-abdominal vessels. The same technique is used when employing the syphon trocar and cannula ; the side tube of the cannula being connected by a long rubber tube to a vessel at the side of the bed.

Some still prefer to use Southey's tubes (fig. 61). These are plunged through the abdominal wall in dependent positions, and after removing the trocar the fluid is allowed to drain off slowly through narrow rubber tubing into a basin at the side of the bed.

C.—Tapping Bladder. Supra-pubic.

This is done to relieve an over-distended bladder when the urethra is impermeable. Especially advisable if patient has to make a journey to hospital.

Site.—Mid-line at upper border of symphysis pubis.

Instruments.—Preferably syphon trocar and cannula.

Technique.—Shave pubis, thoroughly disinfect skin. Through stab puncture of skin plunge instrument smartly, in slightly downward direction, into bladder, just grazing upper border of symphysis pubis; withdraw trocar; turn stopcock. Urine is conducted by side tube into basin at side of bed. Push cannula deeply to prevent bladder wall retracting off its point. When urine ceases to flow, remove cannula, and close puncture as previously described. In certain circumstances it may be advisable to leave cannula *in situ*, but not for longer than twelve hours, otherwise necrosis of skin and infection may occur.

D.—Aspiration of Joints.

Sites.—As in exploratory puncture of joints.

Technique.—Use aspirating trocar and cannula, as in exploratory puncture. To assist in complete removal of fluid, compress joint with hand or elastic bandage applied, *e.g.*, in knee, from below up.

After aspiration and occlusion of puncture by adhesive plaster, place thick layer of cotton-wool all round joint and apply elastic bandage over it. The compression must not produce œdema of the parts below.

E.—Tapping a Hydrocele.

Instrument.—So-called "hydrocele" trocar and cannula.

Technique.—Disinfect scrotum. Hold swelling so that testicle, at back of hydrocele, lies in palm. Approximate thumb and fingers, making tense skin of scrotum and hydrocele sac. Hold instrument as in fig. 60, and stab quickly through skin and sac wall at a spot free from veins or sebaceous follicles. Avoid wounding testicle. Withdraw trocar and completely evacuate fluid. Grasp skin around cannula and pull latter out smartly. Seal puncture with collodion.

OPENING OF CERTAIN ACUTE ABSCESSES.

Acute abscesses should be opened in most cases as soon as diagnosed in order (*a*) to remove the cause, (*b*) to relieve pain, and (*c*) to prevent further destruction of possibly important tissue. Such destruction of tissue and consequent impairment of function corresponds obviously to the extent and duration of the abscess.

The writer finds a drainage tube cut as in fig. 62 to be most useful in the treatment of deep and fœtid abscesses. The unperforated part is cut $\frac{1}{2}$ in. longer than the other, and the whole introduced to the depth by means of a suitable forceps. If, on dressing, irrigation is found to be necessary, the solution is injected through the longer projecting end, is thereby carried to the depth of the wound and returns through the various perforations in the shorter tube.

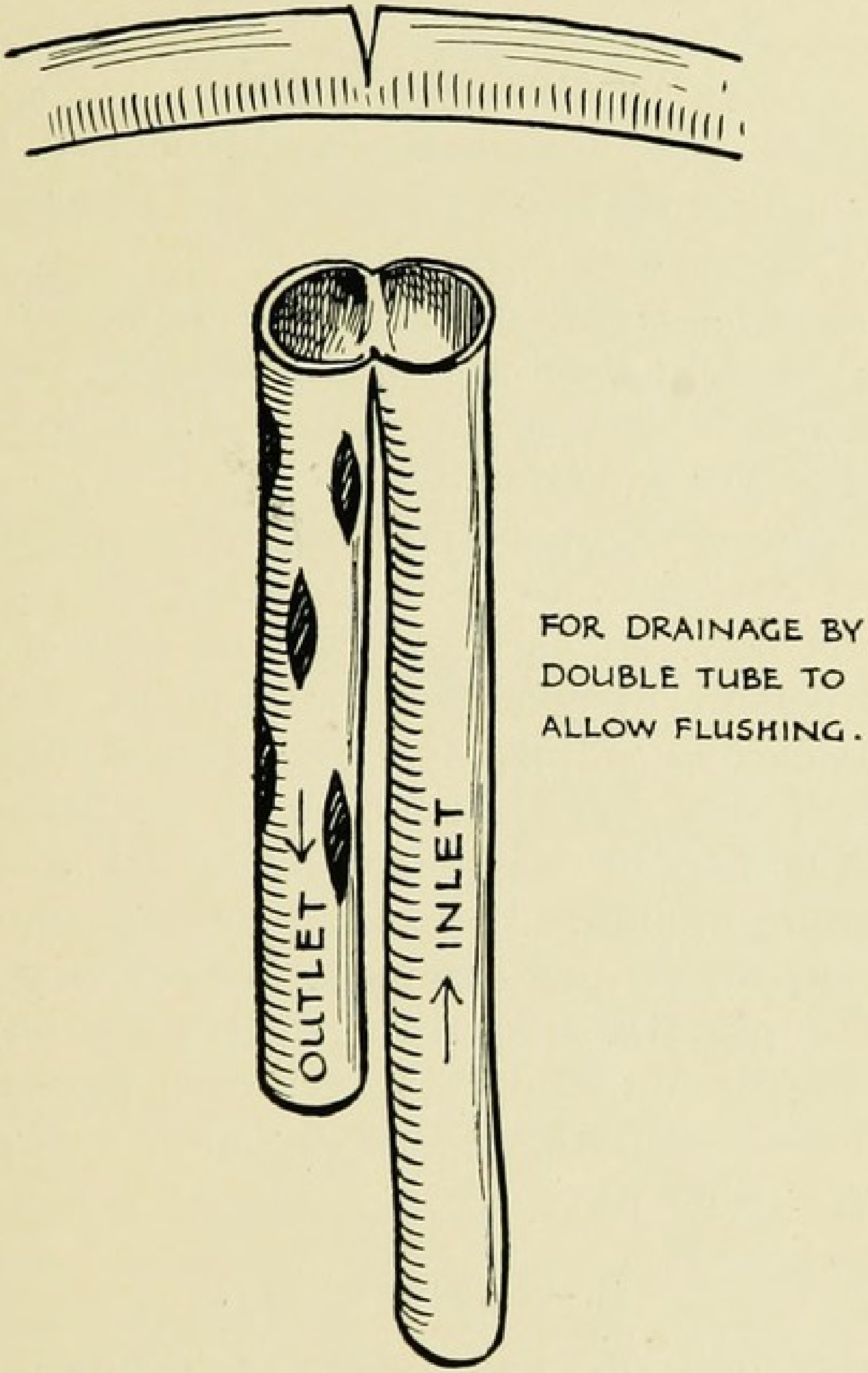

FIG. 62.—Method of cutting rubber tube for drainage of a deep abscess cavity.

Klapp's suction glasses or Bier's congestion should be applied, if possible, in all cases, as healing is materially hastened thereby. Drains should be removed when fœtor ceases or discharge becomes serous. The suction or congestion treatment may be continued for a day or two thereafter.

A.—Post-pharyngeal.

Anæsthesia.—No anæsthetic should be used, because this may inhibit the laryngeal reflex and allow entrance of pus to the respiratory passages.

Instruments.—Mouth-gag; tongue depressor; sinus forceps; straight bistoury with adhesive strapping wound round blade to within ¾ in. of the point; forehead mirror and lamp.

Technique.—Patient should be seated if possible, and the chest covered with mackintosh or towel. Insert gag, direct light on back of pharynx, depress tongue, instruct patient to take deep inspiration, meanwhile introduce bistoury till nearly touching pharyngeal wall. At end of inspiration, stab quickly backwards, cut upwards, and stand clear. Outflowing pus is coughed up during expiration. If opening be large enough (at least ½ in.) no further treatment is necessary than to spray the pharynx frequently with some antiseptic. If opening be not efficient, anæsthetize the surrounding mucous membrane carefully and enlarge with bistoury or sinus forceps.

B.—Submaxillary.

Inflammation in this region sometimes spreads rapidly, and must be treated promptly to prevent pus burrowing under the cervical fascia. If distinctly localized the abscess may be opened by Hilton's method, *i.e.*, ½ in. incision through skin (previously disinfected), and deep fascia; push closed sinus forceps into abscess cavity; open blades, and withdraw; insert drainage tube as described; apply dressings and firm bandage.

If rapidly spreading inflammation as in angina Ludovici, extensive incisions through the superficial structures are required in order to check the spread of the mischief. As far as possible the branches of the facial nerve which loop downwards below the jaw should be avoided. These loops reach, roughly speaking, from behind the angle of the jaw to the corner of the mouth. Such wounds should be filled with gauze wrung out of weak hydrogen peroxide solution until the inflammation has subsided, when they may be sutured.

C.—Parotid.

Anæsthesia.—General or local.

Technique.—Open by Hilton's method. Incise skin and fascia horizontally in upper half, obliquely downwards and forwards in lower half of gland. Open blades of sinus forceps in similar direction, in order to avoid injury to fibres of facial nerve.

D.—Axillary.

Anæsthesia.—General, unless abscess superficial.

Technique.—Abduct arm, shave and disinfect skin. Hold knife parallel to abducted arm, cutting edge downwards, and incise in mid-axillary line, over lower part of swelling. If abscess superficial, pus will be struck at once, insert long drainage tube; if abscess deep, pass finger into wound, feel fluctuating area, plunge in closed sinus forceps, expand blades, keep forceps *in situ*, and before withdrawing pass drainage tubes into abscess cavity.

E.—Mammary.

The remarks made with regard to the early evacuation of acute abscesses are especially applicable here. In the early stages the inflammation may be cut short by applying a Klapp's suction glass of suitable size to the breast, thereby drawing the pus through the nipple.

Anæsthesia.—General as a rule.

Technique.—Half to three-quarters of an inch radial incision into abscess; insert finger, break down septa; insert drainage tube, and wash out excess of pus.

If abscess submammary make free slightly curved incision in circumference of gland at lower and outer part.

F.—Peri-urethral.

Open very early to prevent, if possible (1) communication being established with urethra; (2) consequent possible extravasation of urine; (3) urinary fistula.

Anæsthesia.—General or local.

Technique.—After shaving and disinfecting, make 1 in. incision into abscess, wipe or wash out. Insert double drain, stitching it *in situ*, for three or four days.

G.—Ischio-rectal.

Open early to avoid formation of "fistula in ano." Too many cases of chronic fistula are consequent upon small puncture and inefficient drainage during the acute stage. For this reason the incision must be free, at least $1\frac{1}{2}$ in., and divide if necessary the fibres of the external sphincter. If the cavity is large it should be swabbed out and packed with gauze for three or four days. The bowels are meantime kept confined by opiates. An aperient is then given and the first dressing carried out after the bowels have moved. A very small strip of gauze is then laid in the wound and changed when necessary, care being taken to prevent inversion of edges of skin. The wound is allowed to granulate rapidly.

H.—Peri-articular.

For small abscesses no special technique is necessary. Remember that movement prevents healing, therefore, until this is nearly complete, fix the joint with the exception of passive movement once or twice daily to prevent adhesions.

In large acute abscesses, which frequently arise in connection with bursæ, the writer has used the following method for several years with excellent results :—

The abscess is opened in its long axis from end to end ; the edges of the wound are retracted ; the cavity is cleaned out, sloughs being clipped away ; a gauze strip wrung out of weak peroxide of hydrogen solution is then packed firmly into the cavity. Two to four days later the gauze is removed and the wound sutured, a drain being inserted into any very deep pocket. A thick pad of cotton-wool is applied over gauze and bandaged firmly to prevent dead space formation. The joint is immobilized. Healing usually occurs without further suppuration.

J.—Acute Epiphysitis.

In such cases early operation means possibly the saving of limb or life. In any case it shortens immeasurably the time required for treatment.

Technique.—Over the tender area in the neighbourhood of the epiphyseal line, an incision 1 in. in length is made down to bone. Retract edges of wound and with narrow chisel or gouge, drill or burr, make an opening deep into the bone. If pus be not found at first, try in different directions. A drop or two of pus may be all that is present at the early and most favourable stage. An X-ray photograph may be very valuable in revealing the exact site of the focus. Drain with small tube, and pack excess of cavity with gauze.

K.—Appendicular Abscess.

In cases of appendicitis in which a distinct, fluctuating tumour is present, with œdema of the abdominal wall, the practitioner may with safety proceed to promptly open the abscess. In such a case the abdominal wall, corresponding to the area which is œdematous, forms the anterior wall of the abscess, and pus will be struck without difficulty, by incising in the middle of this area.

The treatment of other appendical abscesses may require very special technique and ought to be left for the surgeon.

Instruments.—Scalpel; blunt-pointed scissors; two blunt hooks; two small wound retractors; six artery and two dissection forcipes; two swab holders; two fully curved needles; catgut, silkworm gut or other non-absorbent suture material; Higginson's syringe;

rubber drainage tube 8 in. long and rather thicker than a lead pencil.

Technique.—Small incision $1\frac{1}{2}$ in. to 2 in. long in middle of œdematous area, parallel to fibres of external oblique. Clamp bleeding vessels; separate fibres of external oblique superficially with point of knife and deepen with handle; retract edges of external oblique with blunt hooks; incise thin fascia covering internal oblique and separate fibres lengthwise by blunt force; insert retractors, removing hooks, and expose transversalis, which is similarly dealt with, and the edges retracted in a vertical direction. The tissues have moist appearance, more marked in the depth; preperitoneal tissues are frequently matted together and adherent to peritoneum, and are yellowish in appearance. These are cut through cautiously till pus is reached. Opening enlarged by Hilton's method and kept patent by retractors; finger introduced and cavity cautiously explored. Concretions must be removed and diverticula drained. If appendix projects into cavity it may be ligatured at its base and cut off. Great care must be observed not to break down adhesions forming wall of cavity. Insert rubber drainage tube to deepest part of abscess cavity, withdraw retractors; cavity may now be flushed gently with hydrogen peroxide (10 volumes), and wound wiped with same solution; excess of peroxide gently squeezed out by external pressure; wound and adjacent skin wiped dry. Catgut sutures inserted only if deep muscles gape unduly. Edges of external oblique drawn together by catgut suture. Skin sutures (silkworm gut) include aponeurosis of external oblique to prevent "dead" space formation.

Dressings.—Sterile or antiseptic gauze and wool as for other abscesses. Large amount of wool placed over rest of abdomen and all kept in place by a firm flannel binder.

Remarks.—Unless a skilled operator, it is unsafe to undertake much manipulation of the abscess cavity. It is therefore better not to attempt to seek out or remove the appendix unless it actually thrusts itself forward. The appendix may be removed at a later date.

Compression by the extensive pad of wool over the abdomen raises the intra-abdominal pressure and tends to force fluid in the direction of least resistance, namely, through the drainage tube. Any tendency to dissemination of septic material through inadvertent rents in the abscess wall is thus prevented.

Patients should be placed in bed in the "Fowler" position.

INFUSION AND TRANSFUSION.

By infusion is meant the introduction into the body of normal saline solution. It is indicated in cases where much fluid has been lost from the body, as in severe hæmorrhage, persistent acute vomiting, or urgent diarrhœa (as in cholera, enteric fever, &c.), in severe shock, and in certain cases of profound toxæmic poisoning. Where the patient is much emaciated from want of assimilation of nourishment a solution of dextrose or glucose (5 per cent.) may be added to the saline used for infusion.

Transfusion of blood requires skilled technique and is not described here.

Infusion may be made : (*a*) Subcutaneously—hypodermoclysis ; (*b*) intravenously ; (*c*) *per rectum*, proctoclysis.

Normal saline solution is best made from prepared sterilized "tabloids" or ampoules of salt, supplied by all wholesale chemists. A supply of these ought to be carried by every medical man. Ordinary table or kitchen salt contains impurities which may be deleterious. The direction as to the quantity of boiled water required is given on each package, or a urinometer may be used; salt is added to cold boiled water till the specific gravity reaches 1012-1014. The temperature of the solution should be about 105° F. (40·6° C.), so that after having flowed through the apparatus it enters the body at a proper temperature (above 100° F.).

All apparatus used must be sterilized. Before introducing the needle the apparatus must be filled with the solution to the absolute exclusion of air bubbles.

A.—Subcutaneous Infusion—Hypodermoclysis.

Sites Selected.—(1) Under the breasts—submammary ; (2) under skin of axilla ; (3) under skin of groin.

Apparatus.—Stout hollow needle preferably bent, funnel, and 4 ft. of rubber tubing (calibre $\frac{1}{4}$ in.).

Technique.—Disinfect thoroughly the site selected for the infusion. If submammary, disinfect at lower and outer margin of breast. Grasp skin with left hand. Stab needle quickly through skin parallel to muscle, so that needle lies in loose areolar spaces behind breast. Solution must run in slowly (1 pint in ten to twenty minutes). If allowed to run in at too great pressure, overstretching of tissues occurs, evidenced by pain, and subsequent ecchymosis. One to two pints may be thus introduced under each breast. The breast projects markedly and the solution may run through the nipple. When sufficient has been introduced, the needle is smartly withdrawn and the puncture covered with a small piece of sterile gauze and adhesive plaster.

The technique is practically identical when the solution is introduced under the skin of the axilla or groin.

B.—Intravenous Infusion.

Apparatus.—Hypodermic needle and local anæsthetic; scalpel; dissection forceps; curved needle and catgut; glass funnel; rubber tubing 4 ft.; glass or metal nozzles of different sizes as in fig. 63.

Technique. — If the patient be not already anæsthetized, a local anæsthetic may be injected over a prominent vein at the bend of the elbow, or other suitable situation. The vein is carefully isolated; a ligature passed around its lower portion and tied. A ligature is also passed round the upper exposed portion and the first loop of a reef-knot made. The wall of the vein is picked up with forceps, and an oblique snick half across the vein is made with scissors (fig. 64). The nozzle of the apparatus is introduced while saline solution is flowing freely through it. The upper ligature is now pulled tightly, gripping the nozzle in the vein. The solution is now allowed to flow, not quicker than at the rate of 1 pint per ten to fifteen minutes. An average amount of from 1½ to 2 pints may be given, but the quantity varies with the amount of fluid previously lost from the body, the condition of

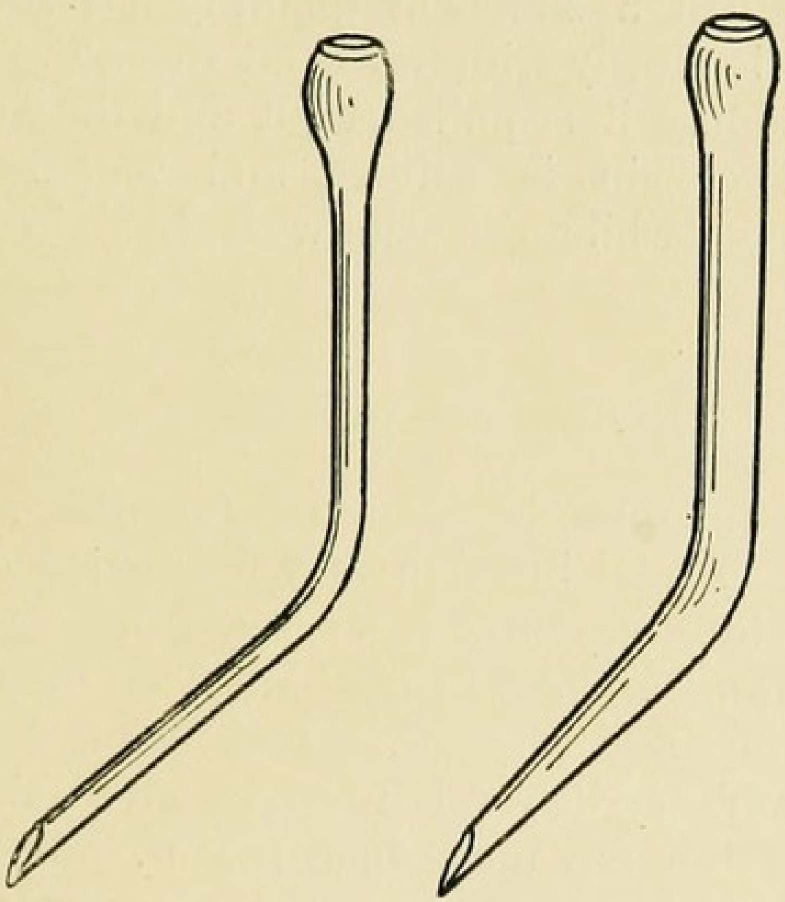

FIG. 63.—Glass nozzles for intravenous infusion of saline solution.

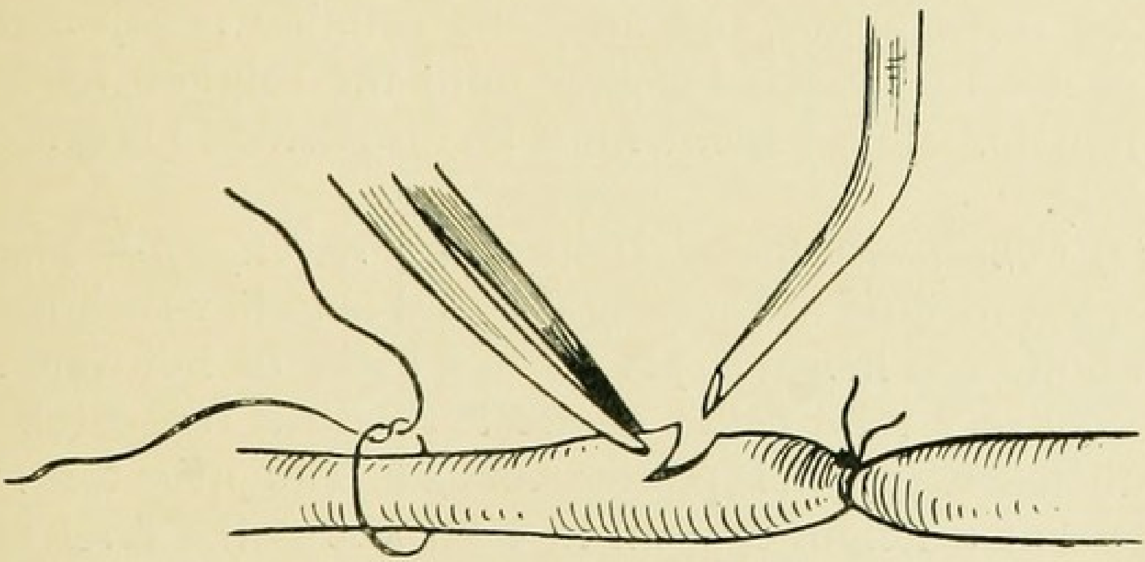

FIG. 64.—Method of tying, cutting, and holding vein for introduction of glass nozzle.

the heart and pulse, and the general condition of the patient. When a sufficient quantity has been given the nozzle is slowly withdrawn, at the same time the ligature holding it is pulled tight and the knot completed. The skin is sutured and the dressing is bandaged on while the elbow is held in a flexed position.

C.—Infusion per Rectum.

The rectum must be cleared before this method is attempted. Rectal infusion may be carried out either intermittently, every three to six hours, or continuously.

(1) *Intermittent Rectal Infusion.*—This may be done with a funnel and tube or, if these be not available, a Higginson's syringe. It must be given slowly and at a temperature not more than 103° F. The quantity taken comfortably at one time varies from 5 to 20 oz.

If the rectum is irritable ♏v. to ♏x. of laudanum or nepenthe may be added to the solution. When sphincter control is weak, the buttocks should be raised on a pillow, and after the solution is injected the nates are pressed together until the solution tends to remain. The patient must be instructed to breathe quietly.

(2) *Continuous Rectal Infusion — Proctoclysis.* — The simplest method of carrying this out is to have a small flat-bottomed irrigator placed in a basin of hot water, the delivery tube being connected with a rectal tube (catheter or special pewter tube). The irrigator is placed at a height of 4 in. to 8 in. above the level of the anus ; the fluid is then found to run in of its own accord ; no clip is required. The pewter tube described

by Moynihan is about the thickness of a lead pencil, is perforated like a vaginal douche tube at its extremity, and is capable of being bent to fit the hollow of the sacrum. Some care is required to make certain that the fluid is being absorbed. Once well started, it may be left *in situ* for many hours. As much as 12 pints in twenty-four hours have been absorbed.

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