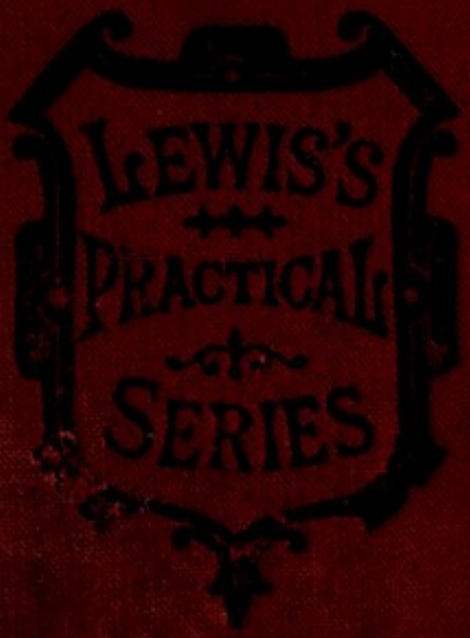
Anæsthetics : their uses and administration.

ANÆSTHETICS



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1892

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ANÆSTHETICS

THEIR

USES AND ADMINISTRATION

BY

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MEMBER OF THE ROYAL COLLEGE OF PHYSICIANS; MEMBER OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND; ADMINISTRATOR OF ANÆSTHETICS AND LECTURER IN UNIVERSITY COLLEGE HOSPITAL, THE NATIONAL HOSPITAL FOR PARALYSIS AND EPILEPSY, QUEEN'S SQUARE, AND THE DENTAL HOSPITAL OF LONDON

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PREFACE TO SECOND EDITION.

In the present edition the bulk of the matter has been recast, and materially added to, with a view to increase its utility. The uniformly kind and suggestive criticisms of the first edition have aided me, and I have in many cases adopted improvements proposed by correspondents and reviewers, notably by supplying woodcuts of most of the apparatus described. In my former edition, the descriptions were given almost in the *ipsissima verba* of the inventors, as it appeared to me that they, if anyone, should know how to describe their own ideas. In the present edition these descriptions have, however, been altered to render them it is hoped more plain.

When opinions are at variance about the action of an anæsthetic, or the value of a method, I have endeavoured to present the arguments fairly, but as

the book is intended rather as a practical manual than as a disputatious treatise, all discussions have necessarily been curtailed. While many of the illustrations are original, some are lent by the courtesy of the firms who make the apparatus they depict, or are placed at my disposal by the kindness of professional colleagues, and to all of these I tender my thanks.

82 Mortimer Street,

Cavendish Square, W.

June, 1892.

PREFACE TO FIRST EDITION.

The introduction of anæsthetics, which has done so much to rob surgery of its horrors, alike for the patient and the operator, has created a great demand for persons capable of administering these pain-destroying agents, without unfortunately exciting, as a rule, so great a sense of responsibility in the administrator as his difficult and dangerous duties should render obligatory.

It is surprising that surgeons who have witnessed the attempts of novices to give anæsthetics, should hold any view save that no one is capable of safely giving any anæsthetic unless he has been carefully taught and has obtained considerable experience.

Personally, I do not believe that the perusal of any book will enable a medical man to do more than learn the rudiments of anæsthetising; but a book may be of

undoubted service to the thoughtful student or practitioner, in enabling him to appreciate the dangers incident to, the caution necessary in anæsthetising, and to grasp the rationale of the various methods of procedure.

Unfortunately, the subject of anæsthetics has for some years escaped the notice of the scientific side of the profession, and has as a natural result been relegated to the domain of routine.

In this book, which has been written purely from the stand-point of every day practice, I have attempted to indicate that the matter dealt with has a scientific as well as a work-a-day aspect, and that he who desires to be more than a mechanical (and hence dangerous) administrator of anæsthetics, must be scientifically, as well as practically, educated in his art.

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ANÆSTHETICS.

CHAPTER I.

Historical.

Means for producing surgical anæsthesia were practically unknown until Wells introduced nitrous oxide, Morton employed ether, and Simpson chloroform. With the first employment of these three agents commences the history of artificial anæsthesia, although from very early times attempts were made to attain painlessness during surgical operations.

Nepenthes or sedative draughts to relieve severe pain are mentioned in the Odyssey—Helen seeks to "drown all sense of woe" and assuage the sufferings of Menelaus. In Egypt, Cannabis Indica, the modern Haschish, and other drugs, were similarly used. The Assyrians and ancient Chinese seem to have employed various drugs with a view of relieving the pain of wounds and such rough surgery as was practised among them. Opium, Cannabis Indica, carbonic dioxide, and deadly nightshade, were advocated in various forms to achieve this object. Pliny and Dioscorides describe several methods in vogue among the Romans and other nations for benumbing parts subjected to incision and cauterisation. Memphis marble, for example, was finely powdered and applied to the part, while on the addition of vinegar a gas was given off (carbonic

dioxide) which rendered the part slightly anæsthetic. Various members of the Euphorbiaceæ, Mandragora, and Solanaceous plants, were also employed as infusions, which being drunk induced some narcotism. Attempts at anæsthesia by inhalation were very early practised. The Scythians burned Cannabis Indica and inhaled its fumes, to alleviate pain.

In more modern times little advance was made until the present century. Most surgeons were contented to put their patients deeply under opium. In 1661, Greatrakes, a professional "stroker," also practised anæsthetic mesmerism. He performed before Charles II. In a M.S. dated twenty years later, one, Denis Papin, wrote that he possessed the means whereby he could abrogate all painful sensations during a surgical operation, but what his method was, is left unexplained.

In the 16th and 17th centuries Valverdi and others operated upon patients stupefied by compression of the carotid arteries, so depriving the brain of blood. In this practice they seem to have been anticipated by the Assyrians, who are reported to have compressed the vessels of the neck to render painless the operation of circumcision. James Moore, an English surgeon, in 1784 revived a suggestion, originally made by Ambroise Paré, that compression of the nerve-trunks should be practised before cutting the areas supplied by them, and John Hunter actually took advantage of the plan, and amputated a leg in St. George's Hospital after firmly compressing the crural and sciatic nerves. Mr. Moore expressed himself satisfied with the result.

A departure in an entirely new direction was made by Mesmer and his followers, who averred that patients thrown into the "magnetic state" (*i.e.* hypnotised)

could be surgically treated without any pain or inconvenience. Long before Mesmer lived, a belief had been current that the natural magnet possessed powers which were both curative of disease and capable of establishing anæsthesia. Thus Cardan (1584) recounts how the magnet could be employed to abrogate pain. The germs of the facts now known and accepted under the terms animal magnetism or hypnotism bore a fruitful harvest of windy words, Paracelsus, Glocenius, Burgrave, and others, contributing largely thereto. By Anthony Mesmer (born 1734) however, the matter was advanced from theory to practice, and although we may carp at Mesmer as a charlatan and quack, we must accord to him a meed of gratitude for establishing upon a practical basis a science which before his age was lost in useless verbiage. In 1766, Mesmer published his work, "The Influence of the Planets in the Cure of Disease," which maintained that the celestial orbs exercised, by means of "animal magnetism"—an all-pervading fluid, an influence benign or malign on human beings. Fourteen years later, in conjunction with a Jesuit called Father Hell, Mesmer undertook the cure of disease by means at first of the magnet and steel tractors, but finally of manual passes. The plaudits which at first greeted him in Vienna were ere long changed for the most hostile treatment, the learned bodies of his own and other countries treating his writings with contempt and himself with contumely. Leaving Vienna, Mesmer exploited Paris, where he founded the widely famed hospital whereat were treated a great number of patients. In 1785 a royal commission was appointed to enquire into Mesmer's pretentions, but this and subsequent commissions unfortunately con-

fused the issues in question, and while they decided that Mesmer and his immediate adherents were unworthy of credence, they failed to discriminate the substratum of truth underlying their teaching and practice. After Mesmer's downfall the subject was kept before the world by the practice of the Marquis de Puységur and the somnambulists. In 1829, Cloquet amputated a breast, the patient being rendered insensible through having been thrown into the hypnotic state. Elliotson, a firm believer in the practical uses of animal magnetism in surgery, employed it on several occasions with success. Braid, of Manchester, in 1841 made considerable trial of what he called the neurhypnotic trance as a means of producing surgical anæsthesia. Similar experiments were carried out in India by Dr. Esdaile, who performed no less than three hundred operations upon patients in the hypnotic state. Spasmodic attempts have from time to time been made to revive the practice of hypnotism for the induction of anæsthesia with but partial success. It has been found that while only a certain number of persons are capable of being completely hypnotised, even these as a rule require several séances under the hands of the magnetiser before the requisite degree of insensibility to pain is attained. Again, the mental state thus called into existence is in a large number of cases highly prejudicial to physical and moral well-being, and hence the consensus of opinion at present goes rather adversely to the employment of hypnotism in anæsthetic practice, save in very exceptional circumstances and under carefully guarded conditions.

In the 18th century the history of discoveries concerning anæsthetic methods becomes merged in that

of the progress of chemical research. Hales, Lavoisier, Priestley, and Cavendish, opened up rich stores of knowledge by their discoveries among the gases. Oxygen, nitrogen, nitric oxide, were prepared and closely studied, and, in 1772, Priestley added nitrous oxide gas to the list. Pneumatic chemistry, till then unknown, became the absorbing theme among chemists, while physicians sought to bring the recent discoveries to account by pressing these gases into the service of medicine. Dr. Beddoes in 1798, assisted with finances by Wedgwood the renowned potter, inaugurated his Pneumatic Institution at Clifton, where he proposed to treat phthisis and many other diseases by inhalations of various gases.

The Pneumatic Institute is interesting mainly because its first superintendent was Humphry Davy, who prosecuted therein his researches concerning nitrous oxide and other gases. In 1799, Davy discovered that "as nitrous oxide, in its extensive operation, appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Davy substantiated his statements by most careful experiments upon the lower animals, extending Hales' research, which had been confined to mice, and demonstrating many facts the practical uses of which were not appreciated for more than forty years later. But his philosophic mind did not content itself with limiting his experiments here; he actually inhaled the gas and found its influence to assuage the pains of toothache, and in his "Researches" are recorded his own sensations and the behaviour of others after inhaling nitrous oxide gas. Early in the nineteenth century Dr. Hickmann sug-

gested that a painless mode of operating might be achieved by the patients' inhaling carbonic acid gas, but his proposal met with scant favour.

The discovery made by Davy was not brought within the field of practical application until Horace Wells, a dentist of Hartford, Connecticut, conceived the idea of using nitrous oxide gas as an anæsthetic for tooth extraction. Wells went to a popular lecture delivered before the inhabitants of Hartford by a Mr. Colton, an itinerant lecturer on chemistry. During the performance one of the audience inhaled an impure sample of gas and became very excited. In the course of his gyrations this individual wounded his leg but felt no pain, a circumstance of which Wells was not slow to take notice. The following day, Dec. 11th, 1844, Mr. Colton at the request of Wells administered gas to him, and during the ensuing unconsciousness, a Mr. Riggs, another dentist, extracted a molar from Wells' jaw. After successfully employing gas as an anæsthetic among his own patients, Wells essayed a public demonstration in the operating theatre of the Boston General Hospital. The individual upon whom this experiment was tried was not rendered completely unconscious, and gave unequivocal signs of having felt pain. This failure not only ruined Wells, who died in great poverty not long afterwards, but discredited nitrous oxide as an anæsthetic.

Colton subsequently induced various dentists to experiment, and in 1867 he was able to give a record of 20,000 successful cases. In 1868* the anæsthetic pro-

* Colton while in Paris met with a well-known dentist, Dr. Evans, mainly to whose energy and munificence Colton's apparatus travelled to London, where the merits of nitrous oxide gas were brought before the English faculty.

perties of nitrous oxide gas were successfully demonstrated at the Dental Hospital of London, and a committee of the leading English dentists was formed. The two reports published by these gentlemen, and read before the Odontological Society of Great Britain, spoke in warmest praise of the agent, and practically established its claims as a safe and efficient anæsthetic for short operations, in spite of considerable opposition on the part of certain members of the medical profession, who denounced nitrous oxide as dangerous and unsatisfactory.

Ether is said to have been discovered by an Arabian chemist, Djabar Yeber, and its method of manufacture by Dr. Michael Morris. As an anæsthetic, however, it is commonly held to be due to American enterprise. It was fairly well known, and its properties recognised, as early as 1785, when Dr. Pearson, of Birmingham, employed it as an inhalation for asthma, and early in the present century it was used in the treatment of phthisis. In 1818 a paragraph appeared in the *Journal of Science and the Arts*, which although unsigned is generally supposed to have emanated from the pen of Faraday; it runs:—"When the vapour of ether is mixed with common air and inhaled, it produces effects very similar to those occasioned by nitrous oxide." Then follows an account of an experience with ether; a gentleman who inhaled became "lethargic," and so remained for thirty hours. Facts about the narcotic properties of ether were rapidly brought to light, and the writings of Orfila, Brodie, Giacomini, and Christison, all give more or less accurate accounts of the stupefying effects of ether. About the year 1840 it was a common trick at lectures and among medical students to inhale ether-vapour in

order to induce exhilaration. A number of lads were indulging in this pastime in the outskirts of Anderson, S. C., and to stimulate further their mirth seized upon a negro boy and forced him to inhale ether, pressing the vapour upon him until he became deeply narcotised and apparently dead. In an hour, however, to the delight of his tormentors, the negro resumed consciousness. This scene impressed itself so deeply upon one of the lads, named Wilhite, that when three years subsequently he became the pupil of a Dr. Long, of Jefferson, Jackson County, U. S. A., he narrated to him his experiences of ether. As a result Dr. Long in 1842 administered ether to a patient, and while he was narcotised removed a small tumour. The same surgeon employed ether as an anæsthetic on several subsequent occasions with a like success, but somehow the matter did not attract any particular notice. Other medical men also about this time employed ether for surgical anæsthesia. A student named William Clarke, in 1842, administered ether at Rochester, New York, to a patient for tooth extraction, and Dr. Marcy, an American, operated upon an etherised patient in 1844.

However, the employment of ether as an anæsthetic is more usually associated with the name of Morton, a dentist of Boston. William T. G. Morton was a pupil of Horace Wells, and from his master he gathered his first impressions concerning artificial anæsthesia. It would subserve no useful purpose to open up the miserable quarrels and recriminations which have been connected with Morton and his share in the introduction of ether as an anæsthetic. I will, therefore, merely state the facts as far as I can do so without bias, and after reading both sides of the controversy.

Wells made Morton his partner in a dental practice he proposed to start in Boston. The removal from Hartford to Boston was consequent upon a discovery Horace Wells had made of some solder with which he hoped to achieve great things. To confirm his own estimate of the value of this solder he called in a Dr. Jackson, a scientific chemist, who expressed a favourable opinion. However, the partners soon fell out, and Wells returned to Hartford, leaving Morton in Boston. The latter asked Wells for information as to the production of nitrous oxide, and was by him referred to Dr. Jackson. It was suggested by the chemist that trial should be made of sulphuric ether instead of laughing-gas, since it was more easily obtained. Acting upon the suggestion, ether was given and teeth were extracted without pain. This success was followed by a public demonstration, October 17th, 1846, in the Massachusetts General Hospital, when Morton administered ether, and Dr. Warren, a well known surgeon, proceeded to operate. The experiment was repeated, and each time proved a remarkable success.

In England, the first administration of ether took place in Gower Street, London, close to University College Hospital, when Mr. Robertson, a dentist, gave ether and removed some teeth. This took place Dec. 19th, 1846, at the house of Dr. Boot.

On December 21st, Liston amputated through the thigh in University College Hospital, the patient being etherised. Dr. Snow, early in 1847, commenced the successful administration of ether in St. George's Hospital, but upon the introduction of chloroform he gave up ether for its more savoury but less safe rival. On January 19th, 1847, Dr. (afterwards Sir James

Young) Simpson administered ether to a woman in childbirth. Notwithstanding favourable experiences of many, ether was not rendered popular for some years subsequently. The methods in vogue for its administration were far from satisfactory; many patients never got beyond the stage of exhilaration and wild excitement, and their struggles and bacchanalian shouts were pronounced highly embarrassing to the presiding surgeon. These considerations led Liston and other eminent surgeons to regard ether with suspicion, and made them diffident in invoking its aid to their assistance. However, up to the time of Simpson's world-famed pamphlet, *Notice of a new anæsthetic agent as a substitute for sulphuric ether in surgery and midwifery*, November, 1847, ether was slowly but surely winning its way as a safe and trusty anæsthetic. With, however, the introduction of chloroform, came the *coup de grâce* to ether. With an almost incredible rapidity chloroform supplanted her elder sister, not only in Great Britain but almost throughout the world; in America, however, many surgeons still clung to ether. The story of the introduction of chloroform is soon told. Sir James Y. Simpson, not wholly satisfied with ether, in obstetric practice, asked Mr. Waldie, the Master of the Apothecaries' Hall of Liverpool, if he, as a practical pharmacist, knew a substance likely to be of service in producing anæsthesia. Mr. Waldie being acquainted with the composition of "chloric ether," suggested that its "active principle," chloroform, should be prepared from it and used. He never carried out his promise to prepare some, and so the desired substance was obtained in Edinburgh, and Simpson experimenting found its use perfectly satisfactory. This

favourable opinion he expressed in his paper read before the Medico-Chirurgical Society of Edinburgh, Nov. 10th, 1847. On Nov. 15th, 1847, Simpson performed at Edinburgh his first operation, the patient being under the influence of chloroform. It is curious to note how narrowly several persons escaped discovering the value of chloroform as an anæsthetic. Thus, chloric ether, a twelve per cent. solution of chloroform (by volume) in spirits of wine, was employed by Dr. Bigelow, of Boston, but without success. Jacob Bell, of London, however, actually produced insensibility by its use as an inhalation, and Sir William Lawrence the surgeon employed it with some success alike in private and hospital practice. Chloric ether was also used at St. Bartholomew's and the Middlesex Hospitals, but the great uncertainty of its action and the expense of procuring large supplies effectually prevented chloric ether from gaining ground as an anæsthetic. Chloroform was experimentally studied by Flourens in 1847, but no practical uses were made of his work. For some while chloroform was believed to be a "safe anæsthetic," an impression to which the language of Simpson's pamphlet rather lent itself, although certainly no explicit statement to that effect can be found. Unhappily this belief received a rude shock when on January 28th, 1848, a death from chloroform was reported at a place near Newcastle-on-Tyne. This untoward occurrence was soon followed by other deaths, and men's minds became anxious. At this pass Snow, with that earnestness and acumen which characterised all he undertook, commenced his researches into the subject.

In 1848, Snow published his "Experimental papers on narcotic vapours."

Although he improved upon the methods in vogue for the exhibition of ether by the invention of his inhaler, Snow did not advocate at all strongly the merits of that vapour over other narcotics. In 1847 he perfected his chloroform inhaler, being actuated by the belief that this anæsthetic kills through being used in too concentrated a vapour. Snow's experience, like that of most others, made him regard chloroform as dangerous, and so in 1856 he was tempted to investigate amylene, which he found to deserve his good opinion. A Committee appointed by the Royal Medical Chirurgical Society of Great Britain tendered their report in 1864, which strongly insisted upon the danger of chloroform and the inconvenience of ether as then administered. Therein were embodied many suggestions, some of which Clover, who had then achieved a high reputation as an anæsthetist, was not slow in carrying to a practical issue. In 1862 he had constructed and published an account of his chloroform apparatus by which he regulated the percentage of vapour administered. Pollock and Warrington Haward in this country were keenly alive to the dangers of chloroform, and they lost no opportunity of urging the use of ether, an advocacy for which we must always feel grateful. But as time went on Clover was less and less inclined to use chloroform. For minor operations he found nitrous oxide gas given by his apparatus to answer best, and he was led to seek some means of prolonging anæsthesia so obtained. This he achieved by the employment of gas in combination with ether, for which he soon devised an admirable apparatus, described in the *British Medical Journal* in 1876. Subsequently his portable regulating ether inhaler was introduced, and it was

mainly by the compactness and efficiency of this instrument that the practical question, how to give ether rapidly and safely, became answered. In 1879 the British Medical Association undertook to re-investigate the question of the relative safety of the various anæsthetics, and appointed a committee to carry out experiments. The conclusions to which this, the "Glasgow Committee," arrived were in favour of ether, as they found chloroform lowered the blood tension and depressed the action of the heart. In 1889 the Nizam of Hyderabad, at the suggestion of Surgeon-Major Laurie, granted a considerable sum of money to re-investigate the question, and the first Hyderabad Commission, working upon small mammals in India, came to conclusions more favourable to chloroform. As these investigations were not held convincing by English experts, a second Hyderabad Commission, in which Dr. Lauder Brunton assisted, went over the ground again, and corroborated the results before obtained. These experiments are considered at length in the chapter dealing with chloroform.

It is undesirable to enter further into detail. The subsequent history of anæsthetics is mainly that of attempts to introduce fresh substances or to modify the modes of administering the old ones. But few noteworthy advances can be mentioned: Snow, Clover, Richardson, in this country, Claude Bernard, Paul Bert, in France, with others, have devoted much time and labour to the scientific questions connected with anæsthesia, but any account of such labours, to be intelligible, would occupy more space than can here be devoted to the subject.

CHAPTER II.

Preparation of a Patient and Choice of an Anæsthetic.

Although the anæsthetist seldom has the choice of time given to him, the selection of a suitable hour for the operation is not a matter of indifference in administering an anæsthetic. The effect of anæsthetisation upon the robust may be considered trifling and transient, yet when the person anæsthetised is an invalid, and either weakly or highly neurotic, it is certainly not so. Individuals are more liable to after-effects of an unpleasant character when their bodily condition is one of nervous exhaustion and lowered vitality. It is then inadvisable, unless over-riding circumstances should exist, to give an anæsthetic after a prolonged fast—for instance, in the early morning before food has been taken. Similarly, it is inadvisable to select an advanced hour of the evening when the body will be spent with a day of activity or suffering. Further, an anæsthetic should not be given within three hours after a meal of solids, as a full stomach impedes the production of narcosis and leads to vomiting. This last occurring during partial narcosis may occasion fatal accidents through solids being drawn into the trachea. It is well, therefore, to select the period of greatest vital activity, and this is found in most persons in the morning or early afternoon. Arrange for a light meal of soft and easily digested matters to be taken three

hours* before the surgeon should arrive. This may consist of milk foods, strong beef-tea, or jellies, etc., varying with the time of the day and the choice of the patient. Weakly persons with feeble heart-action will certainly do well to take a little good brandy or whisky (one or two table-spoonfuls in an equal quantity of milk or water) half an hour or so prior to the operation, though it is not wise to make the administration of stimulants before an anæsthetic a matter of routine. In every instance it is recommended that the bowels be cleared overnight with a purge.

The following is a condensed form of a useful regimen to be adopted at the time of an operation :—

Operation at 9 a.m.

Beef-tea or thin corn flour to be given at 6 a.m.

Operation at 9 a.m., completed by 10; if sickness occur very hot water may be given in sips from a feeder or porcelain spoon. At 2 p.m. Brand's or Edge's essence of beef in jelly; if much thirst ice may be sucked, or iced soda and milk taken.

If very prostrate from vomiting, iced brandy and soda water.

At 6 p.m. a light meal of fish.

Operation at 2 p.m.

Breakfast at 8, tea, coffee or cocoa, bread and milk, fish, no meat.

Beef-tea, if desired, at 10.30.

Operation at 2, over at 3.

Bread and milk or biscuit and tea or cocoa at 7 p.m.

* It is well, unless the patient be in a very feeble state of health, to adopt Clover's rule, and give the last meal five or six hours before the operation.

When nitrous oxide alone is given, these elaborate details may be omitted, though even then it is well, with children especially, to see that they pass water before being anæsthetised, as urination is often performed unconsciously whilst under the influence of gas.

A patient about to be anæsthetised should be placed in the recumbent position, excepting cases of dental operations under nitrous oxide. The clothing should be carefully loosened, corsets quite undone, neck bands left open, and waist belts and strings removed. It is important that the patient be as comfortably posed as circumstances will permit, for while tranquillity of mind and body go far to assist in the production of narcosis, anxiety and uneasiness will greatly retard its accomplishment. He should now be asked to open his mouth, and a quick glance given to ascertain if any artificial dentures or an obturator, etc., be worn. Such, if present, must be removed with as little annoyance to the patient as possible. A further step may be taken in reassuring him by a few cheery words, and if necessary, directions as to how he is to take the anæsthetic. Such instructions are often of real service by giving him something about which to think.

When, however, the anæsthetic is once well on the way, quietness and silence must be maintained; noise —especially in the case of nitrous oxide—militates considerably against easy and tranquil anæsthetisation.

The choice* of an Anæsthetic must depend on

1. The condition of the patient.
2. The necessities of the operation.

* The question with whom lies the choice of the anæsthetic is considered in detail in Chapter XII.

Ether, either in succession to nitrous oxide according to Clover's method, or given by itself, is the best and safest anæsthetic for general purposes, and should be adopted as the routine method of producing unconsciousness before operations. There are, however, conditions which are often held as justifying a deviation from this routine, and these are noticed below. It may be pointed out, however, that, although apparently a long list, these conditions really represent a very small minority of cases when compared with the great number of instances in which ether should unhesitatingly be adopted.

Children.—Infants and young children bear chloroform well, and resent having their mouth and nose covered by a face piece, an objection, although by no means an insuperable one, to the use of ether. In many instances also ether produces much bronchial trouble, so that a better anæsthetic in these cases is the A. C. E. mixture, or one of chloroform and alcohol. Children about five or six years of age should be given gas and ether, unless they are notably the subjects of respiratory trouble. They will probably strongly rebel against having the face piece applied, so that if it be desirable to avoid "a scene," the mixtures of chloroform, alcohol, and ether, may be substituted and given by the open method. Ethydene dichloride is advocated for children by some, but experience proves that it is not taken more readily and does not appear to be in any way safer in its action than chloroform. Although the use of chloroform is unquestionably attended with happy results in the case of children, it must be remembered that deaths from this agent are by no means con-

fined to adults. It cannot, therefore, be too strongly impressed upon the mind that children run a risk, and probably as great a risk, in chloroform narcosis as do adults.

Pulmonary Disease.—Persons of early adult and adult life should have ether given to them, provided always they are free from pronounced pulmonary affections and renal diseases. With regard to asthmatics, and those suffering from chronic cough, dyspnœa, or emphysema, the A. C. E. mixture should be tried, but if the ether in this still gives distress, its quantity may be decreased, or the Vienna compound used instead. And should the patient suffer greatly from the exclusion of air, through the employment of an inhaler, chloroform can be given by the open method, as that substance will not only produce anæsthesia but will obviate asthmatic seizures. For the subject of chronic bronchial disease the choice of an anæsthetic should be made solely by consideration of his symptoms. In the presence of much dyspnœa, diluted chloroform will be found far preferable to ether. Emphysematous individuals with large (bullock's) hearts are always anxious cases requiring great nicety of treatment. On the one hand lies the possible danger of ether producing a water-logged condition of the rigid chest, and on the other a more than probable danger of syncope through the depressant action of chloroform on the enfeebled, dilated heart. In this dilemma I have found the A. C. E. mixture to answer well, though it needs careful watching, as many and grave symptoms may occur during its use. Among persons who have but one available working lung—as when the other is bound by pleuritic adhesions subse-

quent to effusion, or when one is compressed by an effusion or empyema—the choice of an anæsthetic becomes one of difficulty. In such cases ether is badly borne, and chloroform diluted with alcohol is preferable. And again, the heart, in these cases being often so pressed upon or displaced, is intolerant of further depressing effects;* hence extreme caution will be found necessary.

Renal Disease.—Where the kidneys are much damaged and there is considerable danger of suppression of urine, ether is by many held to be contra-indicated. Certainly in many instances no such untoward result has been brought about; still, perhaps it is well to substitute the A. C. E. mixture for ether, for those patients who are the subjects of pronounced renal disease.

Arterial disease, if present in any grave degree, whether fibroid or due to senile change when far advanced, is a contra-indication for the giving of pure ether. The blood pressure would be increased by this substance, the heart's work augmented, and considerable strain imposed upon the diseased arterial walls by which they become in danger of rupture—a result liable to occur in the brain and leading there to the gravest consequences.

For the aged, that is for those over 60 years of age, chloroform is commonly held to be preferable to ether and in many instances this is true. It is, however, true only because persons past middle life are often the subjects of chronic bronchial trouble; they are also frequently diseased in their vascular systems, and upon

* Any sudden change in the posture of the patient is dangerous and must be avoided. On this subject see the article on etherisation by the rectum Chapter IV.

that account liable to be injuriously affected by ether. Old persons too, like infants, are susceptible to a bronchial and laryngeal irritability which ether excites, producing in some distressing cough, dyspnœa, and exhaustion. However, for aged and feeble subjects with weak hearts and depressed vitality, ether, notwithstanding the drawbacks alluded to above, is beyond doubt the best anæsthetic.

In CONDITIONS OF COLLAPSE, *e.g.*, railway smashes, gunshot wounds, strangulated herniæ, ruptured viscera, or conditions when the vitality has sunk very low, as in the case of carcinoma affecting the œsophagus, pylorus, and causing chronic starvation; also in collapse due to severe hæmorrhages or other causes, or provoked by high temperatures, it may be necessary to perform an operation, and it will usually be desirable to administer an anæsthetic. Ether if properly administered is, I am sure, the best and safest anæsthetic for these cases. It should be given from a Clover's inhaler, as when that apparatus is properly handled there need be no dyspnœa or impediment to respiration. Very little anæsthetic is required, and the mask may be taken off during inspiration every three or four respirations. When there is very considerable respiratory trouble complicating the case, the A. C. E. mixture may be substituted for ether and given either by means of an Allis' inhaler, a cone, or upon lint. Still, ether is *par excellence* the anæsthetic, as it not only produces narcosis, but stimulates the heart and aids the circulation.

In MORBUS CORDIS.—It often becomes a question as to what anæsthetic should be employed in cases of organic heart disease. To answer this question we have to con-

sider firstly, the various forms of valvular disease, and secondly, the conditions of hypertrophy, atrophy, and muscular degeneration, as well as the pericardial conditions which interfere with cardiac function.

VALVULAR DISEASE OF THE HEART, except when incompetency at the aortic orifice occurs, does not, *per se*, greatly affect the prognosis about the safety or danger of giving an anæsthetic, although the changes brought about in the vessels, tissues, and organs of the body in general through such lesions will possibly do so. Indeed, it is a fact that in but few cases of deaths from an anæsthetic have the valves of the heart been found diseased at the necropsy.

DEGENERATIONS OF THE MYOCARDIUM.—When the heart muscle has undergone structural changes, the danger in producing anæsthesia is greatly increased. Any alteration in the respiratory or vascular systems induced by anæsthetics imposes an extra strain upon the already weakened and diseased heart—one which it is unable to sustain; hence supervenes syncope. When the heart trouble is not complicated by pulmonary engorgement, œdema or hydrothorax,—is in short largely compensated,—ether should be given and a Clover's inhaler employed. It has been suggested that a cone or towel is safer in these cases, but I cannot think this to be the case, since with a Clover's inhaler you can, by frequently removing the mask or refilling the inhaler bag, give any degree of dilution of ether you require.

When pronounced pulmonary trouble exists and ether cannot be borne, the A. C. E. mixture should be given. Should nitrous oxide be administered in MORBUS CORDIS? I think yes, but if the case is one of advanced disease and the organ is working feebly, it is wise to

supplement the nitrous oxide by allowing it to pass over ether-vapour. This plan has in my hands answered most admirably. Chloroform, whether pure or diluted, cannot be given to persons having diseased hearts without increasing the risk of syncope, which under any circumstances they must run.

Hypertrophied hearts are in practice usually *dilated* hearts, and being so are muscularly at a disadvantage. The same rules given for guidance above will serve here.

Some highly nervous, excitable persons are much terrified by the application of a face piece, and indeed in some few cases the mental distress and terror thus excited may be sufficient to occasion serious indisposition. In cases such as these it is especially useful to employ the A. C. E. mixture upon lint, replacing it by ether from Clover's inhaler so soon as the patient is sufficiently dazed as not to perceive the alteration.

Pregnant women take all forms of anæsthetics well, but if excitable and nervous as they are apt to be, it is better to avoid the coughing and straining which may follow the employment of ether. It will be found, however, that unless very nervous, women in this condition take nitrous oxide followed by ether well—nor are they more liable to after trouble than at other times—in all such instances, as little of the anæsthetic should be given as is consistent with true anæsthesia, since it is manifestly important to avoid vomiting.

From the surgeon's point of view—to decide upon the choice of an anæsthetic is difficult, as it is impossible to lay down hard and fast rules where there will be always conflicting considerations.

Operations about the Head, Face, Trachea and Respiratory Tract.

Brief operations about **the mouth, nose,** or **pharynx,** such as the extraction of teeth, excision of tonsils, opening of abscesses, tearing off mucous polypi, etc., can often be performed under nitrous oxide. With this agent from ·5 to 1 minute of unconsciousness can be expected. If the operation is likely to occupy more than this time, and if the cautery is not to be used, gas with ether should be employed, as this combination will prolong anæsthesia. In operations accompanied by severe hæmorrhage, but which do not need much time, the gas and ether mixture possesses an advantage, inasmuch as the patient rapidly resumes consciousness, and so the danger of blood being drawn through the trachea into the respiratory tract will be avoided. In operations for the removal of **post-nasal adenoid growths,** I have for some years extensively used gas and ether with success. Some specialists prefer chloroform for such cases (i.) because a more profound and lasting anæsthesia is thus obtained, (ii.) because less violent bleeding takes place at the time of the operation. On the other hand, the rapid resumption of consciousness under ether certainly minimises the danger of blood entering the lungs. When the operation is likely to prove a prolonged one, chloroform will be more satisfactory to the operator.

Staphyloraphy necessitates the mouth being open, and it is a matter of consideration that the operator should have free and uninterrupted access to the buccal cavity. To effect this, the patient can be put under the influence of chloroform and maintained so by anæsthe-

tising through the nostril (as described in Chap. V.). The same procedure answers for operations about the **tongue.** (See also Chap. IV).

Removal of the upper or lower jaw should be performed under chloroform, as the cautery is often requisite and the use of a face piece impossible. In extensive removals of growths about the jaws, it is frequently advisable to perform a preliminary tracheotomy, and then give the anæsthetic through a Trendelenburg's tube, at the same time plugging the pharynx.

Operations upon the larynx, *e.g.*, thyrotomy, will require a preliminary tracheotomy, and in these cases I prefer to keep up the anæsthesia by a Junker's inhaler to the afferent tube of which is fixed a catheter. By this means the amount of chloroform given can be more safely adjusted than when a Hahn's tube and funnel are employed. In all the above mentioned cases in which chloroform is mentioned as being more convenient an alternative method exists, namely, rectal etherisation.

Operations about the **eyes** require extreme narcosis, absolute immobility and freedom from coughing being essential. Nitrous oxide and ether, provided the ether be pushed very far, answer well; there is of course the possibility of ether exciting a fit of coughing, which, should the case be one of excision of a cataract, and should a preliminary iridectomy have been already done, may lead to forcible extrusion of the vitreous. But this can only arise when the patient is not sufficiently under the anæsthetic. There is less fear of coughing with the use of the A. C. E. mixture.

In excision of the eyeball, where coughing is not of such moment, ether may be used, and should be pushed

to deep narcosis before proceeding with an operation. For passing probes or slitting up the lacrimal canals, gas is not satisfactory, as the jactitation interferes with the operator; here the use of gas and ether answers every purpose by obviating involuntary movements.

For operations about the **thorax,** a mixture (A. C. E.) is usually more advantageous than chloroform or ether when given alone, so that where there is especial reason for fearing the respiratory difficulty of ether, this agent should be substituted. For tapping in cases of pleuritic effusion, gas is sufficient. Chloroform in cases of empyema seems peculiarly liable to dangerous results, the heart is usually hampered and respiration abnormally performed; several deaths have resulted from chloroform given in such cases.

It is in these operations that rectal etherisation seems likely to be of very great service. (See Etherisation by the Rectum).

Abdominal Surgery.

In dissecting operations, when tranquillity of respiration is desired, as in operating for the radical cure of hernia in young children, a mixture, methylene, A. C. E., &c., must be employed instead of ether, but for all prolonged and exhausting operations ether should be given unless strongly contra-indicated. Thus I have found for cæsarian sections, ovariotomies, hysterectomies and ablation of the kidney, ether if carefully given answers very well.

In Labour.

There is a consensus of opinion in favour of chloroform in these cases, based partly upon the assumption

that this agent is comparatively safe for parturients, and partly upon the more agreeable character of the substance. This assumption, however, is open to doubt, for chloroform cannot be in any way deemed freer from danger in childbirth than at any other time. If chloroform be employed it should not be entrusted to the hands of a nurse or other person unless skilled in its use. The various mixtures answer well in assuaging the pangs of childbed, and are probably safer than chloroform. Ether, though advocated by some, is disadvantageous in these cases, as it may provoke straining, coughing, sickness, and headache,* but for general obstetric operations, and especially where the patient is exhausted and needs stimulating, ether may be usefully employed. In short it may be said that chloroform or the A. C. E. mixture may be employed as an anodyne in labour, ether when surgical anæsthesia is necessary.

* In my private practice I have met with cases of women who after trying chloroform preferred to take ether in their confinements, stating that it produced more exhilaration and general feeling of well-being, while it assuaged their pangs more efficiently than chloroform.

CHAPTER III.

Nitrous Oxide Gas—Laughing Gas or Simply "Gas."

Chemical and Physical Properties.—Nitrous Oxide Gas [N_2O] is a colourless body almost devoid of odour. It possesses a neutral reaction and consists of nitrogen and oxygen in chemical union, thus differing from the air, which is composed of these gases in mechanical mixture. Nitrous oxide gas possesses well-defined anæsthetic properties, which appear to be quite distinct from the asphyxial symptoms frequently accompanying its administration. This gas agrees with oxygen in many of its chemical properties; thus, it supports combustion when ignited bodies are plunged into it. At a pressure of fifty atmospheres and a temperature of 44·6° F. (7° C.), it becomes liquefied, and advantage is taken of this to enable the gas to be carried about in iron or steel bottles, these latter occupying less space.

Nitrous oxide is decomposed at a red heat, but shows no tendency to undergo change at lower levels of temperature. Cold water dissolves more than its own volume of this gas, while hot water dissolves less, hence it is advantageous to collect it over water at 15° C. Alcohol takes it up in a still larger proportion.

Preparation.—Granulated nitrate of ammonia is pounded to ensure its being finely divided, and is placed in a strong glass retort. The capacity of the generator should be one pint to allow of safe decomposi-

tion of three-quarters of a pound of nitrate of ammonia, one quart for that of two pounds. One pound of the salt will make thirty gallons of nitrous oxide gas. The generator is then carefully heated in a sand bath or over a bunsen, after being connected by tubing with wash bottles of at least the capacity of a quart, as indicated in the figure. At 226° F. the salt melts; at 460° F. it gives off gas, and the temperature must not exceed this by many degrees, otherwise nitric oxide will come over, contaminating the laughing gas. The nitrous

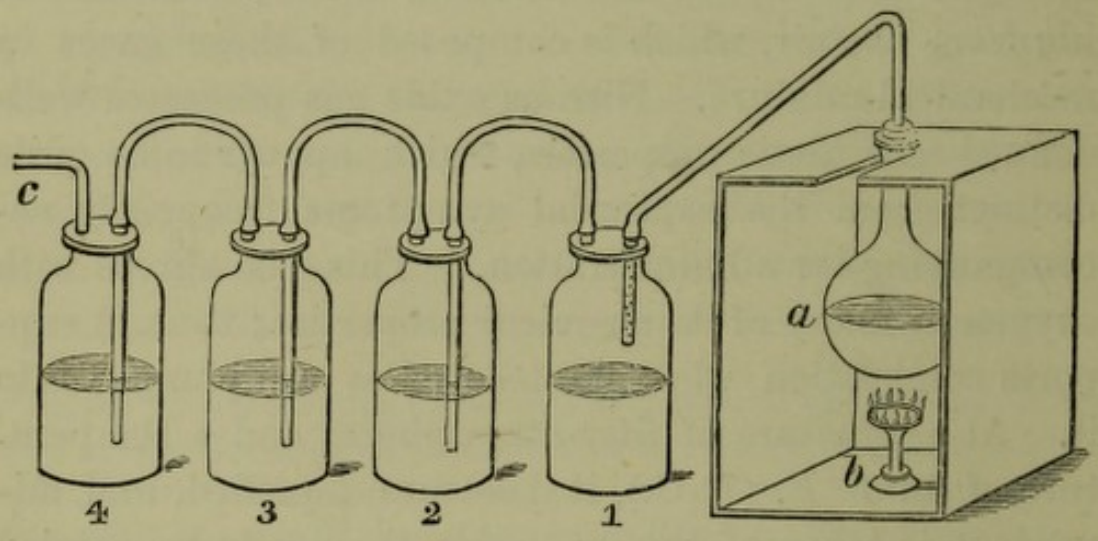

FIG. 1.—Apparatus for the preparation of Nitrous Oxide Gas. *a*. Generator. *b*. Bunsen's burner. 1 to 4. Wash bottles. *c*. Delivery tube to be connected with a reservoir for storing the gas.

oxide should *bubble* over, not *boil* over, not more than thirty gallons being allowed to volatilise in an hour. It is well to have a self-regulating gas jet, which is lowered as the temperature rises too much and *vice versa*. Bottle no. 1 nearest the retort, which may with advantage be placed in cold water, answers the purpose of catching the drippings which come over from the generator; it contains clean cold water almost up to the lower end of the long tube. This tube is per-

forated in order to break up the gas as it passes over, and to ensure its being washed out thoroughly. In bottle no. 2 about four ounces of ferrous sulphate are placed, and water to a few inches added. Bottle no. 3 contains a stick of potash, and water also added. It is sometimes advisable to use an additional bottle or two containing simply water for washing the gas further. Having traversed these bottles the gas is received into the gasometer, which should have a capacity of 30 or 40 gallons. When nitrous oxide is stored in bottles, special apparatus will be needed to force the gas in under the pressure of fifty atmospheres.

The impurities to which nitrous oxide is liable are:—

Sulphates.

Chlorides.

Other oxides of nitrogen, which produce coughing and feeling of suffocation.

Oil (from lubrication of apparatus) which gives a rancid nauseous smell to the gas.

To test for these impurities, let the gas bubble through solutions of barium chloride, which will precipitate sulphates, and through solutions of nitrate of silver, which will precipitate chlorides, while the other adulterations will be detected by the nose.

Purification of nitrous oxide is of undoubted importance, as was shown in the earlier days of anæsthesia, when the most bizarre symptoms were constantly arising, many, if not all of which, were traceable to foreign products being contained in the gas employed.

Some persons prefer the freshly prepared gas, but liquefied gas stored in bottles gives results practically as good.

Physiological Action of Nitrous Oxide—The Vegetable Kingdom.

It appears to suspend rather than extinguish vitality. Seeds will not germinate but remain uninjured when kept in it an indefinite period. Seeds, if sprouting, cease to develop when placed in an atmosphere of this gas, but resume their growth when again placed in the air. Jolyet and Blanche found that plants placed in nitrous oxide gas cease to absorb carbonic dioxide, and do not increase in size. When oxygen is allowed to mix with the nitrous oxide the seeds germinate, and the plants grow.

The Animal Kingdom.

Cold-blooded animals die in an atmosphere of nitrous oxide in two hours. This contrasts with what obtains when the same creatures are placed in indifferent gases, such as hydrogen or nitrogen, for under these circumstances death does not occur for three hours and is preceded by stupor but not true analgesia. Kappeler has shown that frogs placed in it lose reflexes after a very few minutes, whereas the reflexes persist for several hours when the frogs are placed in an indifferent gas, *e.g.*, nitrogen (Goldstein). Sir Humphry Davy, in his careful research, showed that small mammals and birds soon die in it, although when it is mixed with oxygen they live until the oxygen tension sinks to 6 per cent., as against a carbonic dioxide tension of 12 per cent. Exposed to such measures the animals remain sensitive to the last, and it may be

stated generally that mixtures of nitrous oxide with other gases under normal pressure are useless for anæsthetic purposes.

Animals placed in non-respirable indifferent gases become convulsed before death; this does not obtain when they are made to respire nitrous oxide. Their respirations simply grow more and more shallow, and finally cease without any of that *besoin de respirer* which is elicited when simple deprivation of oxygen is practised.

Krishaber experimenting with rabbits found a marked acceleration of the rate of the pulse, with increased force at first in the heart beat. Subsequently where anæsthesia was determined some retardation occurred, while the cardiac rhythm became less regular. Respiration was accelerated and death resulted in two or three minutes. He performed control experiments by ligaturing the trachea. In these cardiac rhythm remained unchanged until after the fourth minute, when the heart beats grew irregular, and ceased at times varying from seven to eleven minutes. The animals remained sentient to the very last. I have repeated these experiments, using dogs and cats in preference to rabbits because these last are peculiarly liable to fright, and this disturbs the rhythm alike of the heart and respiration, and in the main my results agree with Krishaber's. While dogs die in from two to three minutes in nitrous oxide, they do not succumb to asphyxia for five; under nitrous oxide they grow wholly insentient in from fifteen to thirty seconds, while in asphyxia consciousness to pain only ceases with life. Under nitrous oxide I found the heart little affected until the respiration was gravely interfered with, and

then it gradually failed before totally stopping. The creatures seemed under the gas to sink to sleep, and from sleep to pass into death, while when asphyxiated they struggled from first to last.

In the Human Subject.

It is probable that this gas when administered pure, and not mixed with oxygen, enters the blood by diffusing through the thin walls of the air-cells in the lungs. In the blood, a small quantity is dissolved, but the bulk is connected in some loose way with the blood constituents, probably being associated more or less closely with the albumins and albuminoids of the liquor sanguinis and corpuscles. According to Hermann nitrous oxide destroys the red blood corpuscles. The effect of shaking arterial blood with nitrous oxide gas is to darken it, showing that nitrous oxide gas is able to displace oxygen. But whatever union does take place is very unstable, as blood parts at once with its nitrous oxide when left in free contact with oxygen or air.

Under nitrous oxide, the respiration becomes slowed and shallow, and, if the gas be pushed, a complete cessation of respiratory movements eventually takes place. The amount of tissue change occurring in nitrous oxide narcosis is lessened, and so the quantity of carbonic dioxide which the lungs give off is diminished. Subsequently to the administration, the exhalation of carbonic dioxide is increased. The heart beats quietly, fully and regularly under this gas, the pulsations are somewhat slowed in profound narcosis. There is, however, but very slight danger of heart failure result-