A N AE S T H E S I A

IN SOME OF ITS PRACTICAL ASPECTS

BY

J. BOYD JAMIESON, M.B., C.M., F.R.C.S.E.

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I N T R O D U C T I O N

My reasons for choosing Anaesthetics as the subject of my thesis are firstly, the fact that at this time, there is an inclination, in Edinburgh, to use ether far more as a routine anaesthetic than previously; secondly, that from the time that I was a third year student I have taken a great interest in the subject; and thirdly, I have had, since graduation, during four appointments on the Staff of three large hospitals a considerable experience in their administration.

As original observations are considered of higher value than discussion of the opinions of others I have endeavoured throughout my paper to work in, as far as possible, facts that I have observed during this experience. I have administered a general anaesthetic on more than four hundred occasions since 1896, in about two-thirds of which chloroform was used, and in the rest, ether, either alone, or preceded by nitrous oxide, was the agent used. The operations varied from the most complicated brain or abdominal operations to the simplest ones of minor surgery.

Before entering on a dissertation upon Anaes-
:thesia as practised to-day, it will be well to give a short historic sketch of the stages by which modern methods have been evolved.

From the earliest writings known, in the Bible, in the literature of the Greek and Roman Empires, in Chinese writings, dating back hundreds of years before the Christian Era, we find disjointed references, from time to time, gradually gathering strength, to the idea of producing a state of unconsciousness during surgical manipulation. This idea struggling with the rudimentary, mistaken, visionary views of chemistry and physiology, which obtained in these times perverted to the workings of superstition and fan-
:aticism, sometimes apparently being laid aside al-
-together, only to be revived at some later period, but making in reality little progress, until within the last eighty years. Suddenly the long sought for Philosopher's stone was found, and mankind reaped the benefit.

The three principal anaesthetic agents employed at the present time are, in the chronological order in which they were used for anaesthetic purposes :-

Nitrous Oxide(N_2O)

Ethyl Oxide (Ether) $(C_2H_5)_2O$

Trichloromethane (Chloroform) $CHCl_3$.

Nitrous Oxide was discovered by Priestly in 1774, and of course as might be expected was tried as a remedy for various ailments. It was tried in the "Pneumatic Institute" which was inaugurated at Clifton by Dr Beddoes for the treatment of phthisis and other respiratory diseases. Dr Beddoes had an assistant, who afterwards was known to the scientific world as Sir Humphry Davy, the engineer and inventor. A clever painstaking investigator like this, quickly discovered the analgesic properties of the gas when inhaled, and predicted a future for it, but the dis-:covery came to nought no doubt owing to the faulty methods employed in its inhalation. Had men like Sir J.Y.Simpson or Snow been at hand to carry on the investigation then the honour of the discovery would probably have lain in this country, instead of resting in America.

The exciting and peculiar effects of this gas

and the vapour of ether when inhaled, seem to have been pretty well known in this country and in America in 1818, for, in the "English Quarterly Journal of Science and Arts" an article, believed to have been written by Faraday, mentions the fact that "the effect "of breathing the vapour of ether was very like that "of nitrous oxide", but cautioning against its indis-:criminate use, as insensibility had been produced by such inhalation.

The credit however of first producing surgical anaesthesia, rests with an American. In 1842 a Dr Long of Chicago, used ether vapour with the distinct object of preventing pain during a minor surgical operation, and with success, but he never published his results and no one knew anything about his discovery, except of course, his immediate neighbours, until after the rival claims of others, were being contested.

The next step in the advance was the fulfil-:ment of Davy's prediction about nitrous oxide.

In 1844 Mr Horace Wells, also an American, a dentist practising in Hartford, Connecticut, noticed that a person under the influence of nitrous oxide, could be bruised without evincing the slightest pain. This investigator placed himself under the influence

of the gas, and had a tooth extracted, without ex-
:periencing the slightest pain. He tried it with
several of his patients, but unfortunately too soon,
gave a demonstration to members of his profession.
No doubt, owing to the faulty apparatus employed, the
demonstration was a fiasco, and the mortification of
failure, and the ridicule poured upon Wells, acting
upon a sensitive mind ~~no doubt~~ caused the suicide
afterwards of this pioneer of anaesthesia.

The general introduction of this agent was,
by this unfortunate mishap, put back for over nine-
:teen years.

Still another advance was made in 1846, when
a former pupil of Wells', also a dentist, Mr William
G.Morton, wished to try nitrous oxide for the purposes
of anaesthesia in dentistry, but, on the recommenda-
:tion of Dr Charles Jackson, a well known American
chemist, tried instead, the vapour of ether. He was
successful in several cases of tooth extraction,
when his ambition led him to think, that it might be
of use in more prolonged operations, and, on 17th Octo-
:ber 1846, he publicly anaesthetised a patient on whom
a major operation was performed. The patient felt
no pain whatever, from the beginning to the end of
the operation. Unfortunately no sooner had the

success of the new discovery been established, when a long and acrimonious discussion arose between Jackson and Morton, as to whom the honour was due. This ignoble strife was mixed up with quarrels as to patent rights, and was embittered by partisans on both sides. It resulted in the ruin of Morton, who, after spending a few years in poverty, although he lived to see the greatness of his discovery assured, died ~~poverty~~ a disappointed man. It is a curious fact that two of the pioneers of what has proved an in-:valuable boon to the human race should die in misery.

The success of this operation and its pre-:liminary inhalation, were communicated by the famous American surgeon Dr Bigelow, to this country, and, on the 19th December 1846, Dr Boot tried ether success-:fully in a tooth extraction. Two days later, Robert Liston the great surgeon, amputated a leg at the thigh while the patient was under ether, with freedom from pain, and this, was the first major operation done in the British Isles under a general anaesthetic.

On the 19th January 1847 Dr J.Y.Simpson ex-:hibited ether for the first time in midwifery prac-:tice, and proved that the pains of labour might be abolished without interference with uterine contrac-:tion, and that both mother and child were benefitted

by the lessened exhaustion produced by a difficult labour, under anaesthesia. This year also marked the introduction by the same man, of the third, and per-:haps the greatest, of the anaesthetics now generally in use, namely, chloroform. In the words of Professor A.R.Simpson, in his inaugural address to the Glasgow Gynaecological and Obstetrical Society, on 19th Janu-:ary 1897, "The mind that riddled the student note "books with points of interrogation, was bound to "enquire whether nature had not concealed among her "treasures, some other agent, that might be possessed "of all the anaesthetic properties of sulphuric ether, "without some of its attendant drawbacks". Professor J.Y.Simpson noticed that ether had to be administered in large quantities, (the open method was at that time the only one known) the vapour was very inflam-:mable, the cold produced by the rapid evaporation, coupled with the somewhat irritating vapour of ether, occasionally gave rise to bronchitis or even pneumonia, and its odour was disagreeable and hung about both surgeon and patient. Accordingly he began a series of experiments with various substances such as acetone, iodoform, benzine, &c. By accident Dr Simpson on the evening of 4th November 1847, remembered that he has a small bottle of "terchloride of formyle", which had been given to him by a Mr Waldie, a Linlithgowshire

friend, who was a Liverpool chemist, and this sub-
:stance although its weight made it apparently a very
non-volatile substance, was tried simultaneously by
Dr Simpson and two of his friends and assistants
Drs Keith and J.M.Duncan. Hilarity followed by in-
:sensibility, was the effect on all three, and after
a few more experiments Dr Simpson was able to exclaim
"Eureka". Simpson introduced his new anaesthetic to
the profession by an address which he delivered to
the Edinburgh Medio-Chirurgical Society on 10th
November 1847.

Considering the triumph which had already attended the introduction of anaesthesia in America, it would be thought, that the introduction of chloro-
:form with its apparent advantages, would be universally hailed with acclamations, but no, human nature is the same, all the world over. A furious opposition immediately arose, clerical, medical, and lay critics and scoffers assailed Simpson; the same sort of thing which had helped to embitter the lives of Wells and Morton and had driven them to poverty and insanity. But the pioneer of chloroform was a man of very different metal from the pioneers of nitrous oxide and ether. A genius, a powerful and pungent writer, a man who had already a world wide reputation, was

not to be snuffed out like the far less influential and gifted Americans. Simpson met his opponents, whether clergymen, medical men, or mere irresponsible scribblers, with their own weapons, and with many a refutation and castigation, he established his dis-:covery upon a firm basis. The use of chloroform became general throughout Europe, and displaced ether to a considerable degree in America, and so another triumph was added to those which have made the Edinburgh School of Medicine world famous.

Before tracing the advance of anaesthesia, it is of great interest to note that, although ether was administered by inhalation for the purpose of produc-:ing general anaesthesia during about eleven months in Europe and about sixteen months in America before chloroform was introduced, yet no death was recorded as having been caused by its use during that period, except one at Auxerre in France, which on investiga-:tion, appeared to have been rather produced by As-:phyxia than by the action of the ether. (Snow on Anaesthetics p.22). Considering that the agent was used quite empirically, and that the physiological action of anaesthetics was quite unknown, and that the method of administration was extremely crude, and rough and ready, this is a very significant indication

of the comparative safety of ether as an anaesthetic. Chloroform, on the other hand, had not been in general use for three months, when a fatal case was recorded at Newcastle-on-Tyne, in the person of a young woman called Hannah Greener. This occurred on 28th January 1848, and effectively dispelled the idea which had been entertained, that chloroform was absolutely safe. From time to time casualities occurred, and a reaction became manifest against the new agent, but years passed by without any serious enquiry being made into the pharmacology of anaesthetics, methods of administra-:tion, after effects &c., until Dr John Snow, a York-:shire medical man, gave up a large part of his life to the study of anaesthetics, in general and chloro-:form in particular. This writer, with most painstak-:ing exactness, examined anaesthetics from a physical, clinical, and pharmacological standpoint and helped to place the administration on a scientific basis. His text book although published in 1858, is a mine of information, and although several minor points have been refuted with the increase of knowledge, yet in the main his theories are still accepted, and he is to this day quoted as an authority; summed up by Dr Frederick Hewett - himself one of the greatest living authorities on anaesthetics and their adminis-:tration - we find that, "He was the first to describe

"the effects of definite percentages of chloroform "vapour and air. He pointed out that chloroform "fatalities were due for the most part to direct cardiac "paralysis produced by the drug". (This has been somewhat modified by more recent research but this will be described under the head of physiology). "One of the results of his indefatigable labours, was to direct attention to the hitherto unrecognised fact that by careful attention to detail, deaths during anaesthesia could be to a large extent avoided!" (Hewitt Anaesthetics p.12).

After the death of this worker in 1858, the study of the scientific side of the subject remained in abeyance, the practical side having several more deaths added to the roll, until 1862 when Mr J.T. Clover, began to carry on Snow's researches into fixed proportion of chloroform vapour and air. He used modifications of Snow's apparatus practically in a large number of cases, but gradually he became convinced that chloroform was a much more dangerous agent than ether, especially <u>if used in an apparatus which tends to diminish a free air supply</u>, and so he turned his attention to the making the administration of ether, which had hitherto been administered by the open method, and accordingly had the inconveniences

already mentioned, more exact and convenient. His inventive mind produced the inhaler which now bears his name (see illustration), and which, although it has been modified from time to time in details, is still used generally throughout the world when ether is administered.

With the spread of scientific knowledge, it was only natural that anaesthetics should be more and more studied, and accordingly we find in 1864 a Committee of the London Medical Chirurgical Society appointed, to enquire into "the uses and the physiological, therapeutical, and toxic effects of chloroform". The report of this committee argeed in the main with Snow's conclusions as to the danger of concentrated vapours, and strongly recommended a mixture of alcohol, chloroform, and ether, which is now known as the "A.C.E. mixture".

In 1867 in France, Claude Bernard and Paul Bert were working out the subject, as was also Benjamin Ward Richardson in England. The latter introduced in that year a new anaesthetic agent known as "bichloride of methylene" which enjoyed a brief reign but was proved to be nothing more than a mixture of methylic alcohol and chloroform. This same year Dr

Junker introduced his apparatus, which has fallen under the anathema which is laid on all forms of apparatus for chloroform administration in the Edin-:burgh School, but which is really very useful in some cases of operations about the mouth, throat and nose. (Med.Times.and Gazette 1867 Vol.II.p.590, 1869 Vol.I.p.171).

At this time also, after being shelved for nineteen years, the administration of nitrous oxide began to attract attention among dentists in America. In 1864 Mr Rayner, a London dentist, recorded several successful cases of tooth extraction under nitrous oxide. In 1867 a demonstration was given in the London Dental Hospital, and after the issue of a re-:port conjointly with the Odontological Society which was very favourable, its use in the profession of dentistry became general.

Meanwhile in England, where the Coroner's in-:quest was in vogue, the number of fatalities from the use of chloroform began to alarm the profession, and this is not to be wondered at, as, however clean a general practitioner's conscience may be in the matter of careful administration, he cannot, as he is dependant on his profession for a livelihood, con-template with equanimity passing through a Coroner's

Court as a witness in the enquiry into the death of one of his patients under chloroform administered by himself. In consequence of this feeling, a fear of chloroform began to spread in England and Ireland especially among country practitioners, and the use of ether became more and more general. Indeed so marked became this feeling that Scottish graduates, trained in the administration of chloroform, have been repeatedly unable to obtain assistance from their English colleagues in their operations in general practice, unless they would consent to use ether instead of chloroform. In Scotland however, whether owing to different temperament, climate, dietetics, or the result of a more careful practical training of medical students in the administration, or more probably the absence of the careful enquiry into each fatality which obtains in England by means of the coroner's inquest, chloroform retained, until within the last few years at least, the position assigned to it by the genius of Sir J.Y.Simpson. Within the last few years however, even this last line of defence has been intruded upon by the use of the safer ether and, in the great surgical centres, ether is more and more coming to be the ~~substitute~~ agent employed for routine operations, and even the original stronghold of Edinburgh

the last to fall, has witnessed the advent of two medical gentlemen whose entire speciality is the administration of anaesthetics, and the writer recently witnessed a "tutorial" in which the use of Clover's inhaler was demonstrated to students of the clinical surgery class. There is also talk of appointing an official tutor in anaesthetics in the Edinburgh Royal Infirmary so that the medical student will have acquaintance with ether as well as chloroform.

To return from this digression to the history. A heated controversy arose between the partisans of ether and those of chloroform, the former declaring that accidents from the use of ether were always to be explained by some pathological conditions superadded to the narcosis, while the partisans of chloroform stated that the deaths in their hands were due to surgical shock, rather than from the toxic action of the drug, and that if the respiration were watched and the pulse disregarded, chloroform was perfectly safe.

Not unnaturally the greatest champions of chloroform belonged to the Edinburgh School of Medicine. Syme, the great Scottish surgeon, laid down rules for the safe administration of chloroform which have been carried by Edinburgh graduates to all parts

of the world. Those rules were :-

I. Give plenty of chloroform.

II. Watch the breathing and let the pulse take care of itself.

III. If the breathing fails pull out the tongue.

In 1879 the Glasgow Committee of the British Medical Association, made a physiological research into the physiological action of chloroform. The report stated that the blood pressure, and cardiac action under chloroform were distinctly lowered, and ~~stated~~ that, while respiration usually failed first, yet the reverse might occur. This was in harmony with Snow's view but opposed that of Syme.

More light was cast upon the subject by another Commission which was appointed through the generosity of the Nizam of Hyderabad. This Commission which was reinforced by one appointed by the Lancet in 1891, afforded a complete vindication of the teaching of Syme, with which several of the members, being Edinburgh graduates, were perfectly familiar. But finality was not yet reached, for a number of well known physiologists, such as Leonard Hill, McWilliam, Gaskell,

and others, kept working at the subject, and came to the conclusion that the technique of the Hyderabad Commission in some respects nullified its conclu-:sions, and that the matter was not yet settled. The researches of these men have definitely proved however, that, whilst it is perfectly true as Syme pointed out, that the respiration usually fails before the heart does, yet it is the effect of the drug on the circulation that causes this failure, and not its influence upon the respiration which is the character-:istic and principal element in chloroform syncope. (Hewitt Op.cit. p.17).

On the practical side, while very little advance has been made in the technique of the safest and most convenient methods of administration of anaes-:thetics, since Clover by the introduction of his inhaler enabled the adminsitration of ether to com-:pete with that of chloroform, yet there have been devised, by various workers, however, several important modifications in procedure, which have made the use of nitrous oxide, more general apart from dental work, in which it is used to an enormous extent, being perhaps admin-:istered fifty times to every single administration of either of the other two commonly used agents. These modifications then, have given to this gas a place and

an increasingly important one in general surgery. This will be discussed however in a later part of this dissertation under the head of"Methods of Ad-:ministration".

In 1891 the British Medical Association appoint-:ed an Anaesthetics Committee (B.M.J. Vol.II. 1891 p p.1088) "to enquire into the clinical evidence with regard to the effects upon the human subject; and especially the relative safety of the various agents employed, the best methods of administration and the best methods of restoring a patient in case of threatened death". It will be noticed that, unlike the various commissions &c. already mentioned, that this committee had nothing to do with experiments on animals, &c., but was purely to obtain clinical evi-:dence. The report will be considered later.

Other anaesthetics than the three mentioned have been tried, such as amylene, bromide of ethyl, bichloride of ethyl, and several of these will be discussed at a later period.

As a fitting conclusion to this short histor-:ical notice of a vast subject, it may be well to quote an article by Dr Hewitt (Anaesthetics p.18)

"Four distinct phases or stages in the evolution

in this brance of medical science, may in fact be recognised.

(1). In Wells' and Morton's day, the sole object of the administration was the simple prevention of pain during the surgical operation. It mattered not if the patient were to a certain degree unpleas-:antly conscious of his surroundings and shouting, struggling, or other manifestations of what we now term imperfect anaesthesia, were looked upon as a necessary part of the programme.

(2). With increasing knowledge it came to be recognised, that anaesthetics might with safety be administered to such a degree, that absolute uncon-:sciousness, not only of the operation, but of every incident connected with it, could be relied upon, and when the operation was of such a nature that it could not be performed under a single administration of the drug, the inhaler or handkerchied was reapplied. It was not thought advisable (as is obvious from Snow's writings) either to maintain anaesthesia for any great length of time or to keep up a very deep unconsciousness. Reflex movements and vocal sounds therefore were the rule rather than the exception, and surgeons cheerfully accepted the accompaniments of this form of anaesthesia as more or less inevitable.

(3). That deep and tranquil narcosis might safely be maintained even for operations of long dura-:tion now began to be realised, and modern surgery is not a little indebted to this development, in as much that it has rendered possible the performance of opera-:tions which would otherwise have been impossible. Clover was the great pioneer in this direction. Until within quite recent years the induction of anaesthesia was almost necessarily accompanied by inconvenient excitement now :-

(4). It is possible with rare exceptions to prevent this initial intoxication, and to rapidly and safely plunge patients into the deepest anaesthesia."

Such roughly is a summary of what has been a gradual development in knowledge, from the beginning of one of the outstanding eras in medicine, if not the greatest one. The position of the different anaesthetics in various countries has undergone modi-:fications and gradual changes, but at present is somewhat as follows. On the American continent, the birthplace of Ether administration, chloroform never quite displaced its great rival, and although it was given a fair trial, yet ether as a routine anaesthetic was mostly used. Now they are used as seems most convenient in the special case undergoing operation pretty much as is the case in this country. In Britain

the genius of Simpson caused at first the administra-
:tion of ether to fall into complete abeyance, especi-
:ally as an inconvenient and often inefficient method
of administration, namely, the open one, was used.
Clover as has already been described led the way with
a safe and convenient ether inhaler, and in England,
ether began to displace chloroform, especially as
the number of fatalities increased. In Scotland the
introduction was more gradual, but more and more, is
there a disposition to substitute ether for chloro-
:form as a routine anaesthetic. Throughout the
continent chloroform is largely given, but ether is
also administered to an increasing extent. This is
the rule throughout temperate climates both in British
and foreign colonies. But in hot, and tropical
climates, the rapid evaporation of ether renders it
almost impossible for it to be used, hence throughout
British India chloroform is <u>par excellance</u> the
anaesthetic.

INHALATION.

Before going into anaesthetics in detail it will be instructive to glance for a few moments at the introduction of drugs into the animal economy by means of the respiratory tract, known as Inhalation. The taking advantage of the immense absorbent sur-:face of the respiratory tract, is used in medicine to a comparatively limited extent, viz:-

I. When it is desired ~~to~~ to suddenly or very quickly place an individual under the influence of a drug, for example the production of anaesthesia, or the exhibition of nitrite of amyl for the relief of angina pectoris.

II. To administer a gaseous body such as oxygen or nitrous oxide.

III. To produce a local effect on the air passages as when the gum resins are inhaled in the vapour of hot water in laryngeal conditions.

For the purposes of this paper we may discard III.

If a volatile substance, or the tube conveying a vapour or gas, is held in proximity to the in-:spired current of air at the mouth or nose of an individual or animal, the result depends upon a series of physical and physiologico-chemical causes.

(1). We have evaporation from the material, we have the vapour or gas mixing in various proportions with the inspiratory air stream, we have diffusion into the infundibula and the air vesicles, we have diffusion through the capillary walls and absorp-:tion by the blood plasma and haematocytes. So far the change is purely physical and obeys definite and known laws concerning temperature, barometric press-:ure, rate of diffusion, &c. &c.

(2). After the vapour or gas is absorbed we are unfortunately upon far more unknown ground, as it is not quite known how the different agents are com-:bined or carried in the blood stream. Various ob-:servers have described changes in the blood elements but this will be afterwards dwelt upon. The blood plasm has also some relationships with the various agents which are of importance. This second stage in the history of the inhaled substance belongs both to physics and to the domain of physiological chem-:istry.

(3). The absorbed substance passes into the general circulation, and having inhibited or modified the various vital processes by its chemical or physi-:cal activity, is excreted out of the system. This excretion may be by any of the emunctory channels, but in the case of bodies which are absorbed by the

respiratory tract, the greatest and most important route of excretion is the same as that of entrance, namely, the respiratory tract. Drugs that are quickly absorbed are quickly eliminated, and thus, if an ani-:mal is to be put under the influence of a drug by the respiratory passage, and is to be kept under, plainly a balance must be struck between the absorp-:tion and the excretion which will keep the animal in the required state. If more be given than can be excreted of course naturally the effects will be more profound, culminating in the death of the animal if this overdose be persisted in, whereas, if the administration proceeds too slowly, the excretion re-:maining constant, the effects on the organism will be much less general. As most of the substances used in the production of general anaesthesia are selective in their action, and the various centres of the nerv-:ous system are acted upon at various levels of satu-:ration, it follows, that anyone who is to act as an administrator of any of the agents should have some knowledge of the various agents employed. The first worker who applied the study of physical laws to anaesthesia, was undoubtedly Snow. He was quickly followed by Benjamin Ward Richardson, who recorded a large number of interesting facts about various vola-:tile substances and gases, after their inhalation.

All these facts are interesting from a scientific

standpoint, many of them are interesting from a prac-:tical one.

When a vapour or gas is mixed with the inspired current of air the resulting mixture varies greatly in its proportions. This variation depends upon the method of administration, proximity to mouth or nose, volatility of the agent, temperature, barometric pressure, &c. With an impure mixture of vapours or gases the absorption will depend greatly upon their partial pressures in the alveoli. Taking the three best known agents, it may here be stated, that Nitrous Oxide can be breathed pure, i.e. unmixed with air, but the vapours of Chloroform or Ether cannot be obtained pure, far less inhaled, so that there is al-:ways a proportion of atmospheric air present.

NITROUS OXIDE-(N_2O), is a gas of sp.gr.1.52 taking air as 1. Soluble in its own volume of water at $0^{\circ}C$, solubility diminishes as the temperature rises. It liquefies at a pressure of 30 atmospheres at $0^{\circ}C$. It is supplied in steel bottles which contain the liquid form, and roughly speaking 15 ounces of this liquid gives 50 gallons of the gas.

Impurities. As the gas is supplied by the large manufacturing firms the presence of impurities is extremely rare. The commonest one is admixture

with air or oxygen. Dr Hewitt had one suspected sample analysed and it was found to contain 5.2 per cent of oxygen. As in the usual method of administration it is important to exclude air or oxygen the presence of this impurity is of some practical importance. Other oxides of nitrogen have occasionally been present, and may be detected by passing the gas through an acid solution of ferrous sulphate, which will, if they are present be darkened in colour. When I first began to work with nitrous oxide gas, I have a distinct recollection of a certain bottle of gas, the contents of which absolutely failed to produce anaesthesia in three different individuals, and although there was some degree of confusion, little excitement was produced. Unfortunately no analysis was made, but in the light of subsequent experience it is probable, that a proportion of nitrogen was present in that particular sample. Mixed with air or oxygen, the action of the gas when inhaled, varies greatly with the method of administration, or with the individual, &c. as will afterwards be described. After a full inhalation, there must be a certain mixture of the gas with the residual air in the respiratory tract, but with subsequent breaths, of the pure gas, this must be less and less rich in oxygen, and richer in nitrous oxide until after six or seven breaths, the remaining face piece, of course pretty tight, the patient is to

all intents and purposes breathing pure nitrous oxide. At first it was believed that decomposition took place in the circulation and that the intoxicating effects were due to the liberated oxygen. In these days however as has already been pointed out, the method of administration was very faulty for we now know, that the excitement produced by inhalation of the gas, which gave it the name of "laughing gas", is caused by mixtures of the gas and air. It was found however, that it required a high temperature to cause the disassociation into its elements of the molecule. Frankland found no traces of decom-:position in the expired products. (1). Hermann found that simple absorption took place, and that at the temperature of the body, 100 volumes of blood absorbed 60 volumes of the gas. (2). The next idea was, that the gas simply displaced the oxygen combined and in solution in the blood, and that the action of the gas was just the same as hydrogen, nitrogen, or any other neutral inert gas, and that anaesthesia was just the result of internal anoxaemia interfering with the metabolism depending upon oxida-:tion. Rebouly & Merat found (3) that inhala-:tion of pure nitrogen quickly destroyed conscious-:ness, and produced complete insensibility to pain, and this occurred when it was inhaled with small quantities of oxygen, and this has been confirmed by

Burdon Sanderson (4) and Hewitt. But the anaes-
:thesia so produced was shorter than that of nitrous oxide, and took 4 to 6 minutes to produce. But Andrews of Chicago (5) pointed out, that nitrous oxide might have an anaesthetic effect (which was far more prolonged than that of nitrogen or hydrogen) even when mixed with enough oxygen or air to prevent anoxaemia. It may be stated here, that there is a practical method of administering nitrous oxide with oxygen, which aims at having the patient deeply enough narcotised for tooth extraction, yet in which the characteristic cyanosis produced by inhalation of pure gas, does not occur. So it may be conceded that the gas has a specific action on the nervous system. While this has undoubtedly been proved by Paul Bert as well as the observers already mentioned, we must not forget, and, this holds true in all anaesthetics, that the ultimate effect may be due to some form of deoxidation, for we know that the effects of varying amounts of carbon dioxide and oxygen in the circula-
:tion, modify profoundly the action of the anaesthetic agent used, and the remembrance of this, is the funda-
:mental principle of the safe practical administra-
:tion of anaesthetics. So we find that it is very difficult, when we consider the various phenomena produced by the inhalation of nitrous oxide, to say, "this is due to the nitrous oxide", and "this is

"due to the carbon dioxide", while again, "this symptom "is a sign of the want of oxygen". The effect is bound up in a compact whole, which is difficult to unravel. Death from the prolonged administration of nitrous oxide is the result of want of oxygen, and a post mortem examination of an animal killed by being placed in an atmosphere of pure nitrous oxide, shews appearances exactly like those of asphyxia . The right cavities of the heart are full and the left empty. The heart goes on beating for several minutes after respiration has stopped. The respiratory arrest is due to muscular spasm, and not due to muscular paralysis. On examination, the blood is found to contain no oxyhaemoglobin, as the tissues have used it all up, and so the characteristic spectrum of oxyhaemoglobin is absent. But the gas apart from asphyxia, has no permanent poisonous effect, although it is, as has already been stated, slightly depressing to the nerve centres. This fact was proved by M.Martin (6) who kept a dog for three consecutive days under deep anaesthesia with the gas, supplying enough oxygen of course to keep up life. The dog recovered perfectly, within thirty-five minutes.

The action of gas clinically will be discussed with that of ether and chloroform.

ETHER. $(C_2H_5)_2O$. Vapour density (air as unity) 2·586)

Unlike chloroform, there are several ethers in the market which vary somewhat in specific gravity and boiling point, but most of which can be used for the production of anaesthesia.

I. Ether. B.P. sp.gr. ·735 (made from ethylic alcohol)

II. Ether. Purificatus sp.gr. ·720 (made from Ethyl alcohol)

III. Absolute Ether (methylated) sp.gr. ·717-719 (made from methylated spirits)

IV. Rectified Ether, sp.gr. :720-725 (made from methylated spirits).

V. Methylated Ether sp.gr. ·730 (made from methylated spirits).

The specific gravity of pure ethylic ether, can-:not be got lower than ·720 at 60° F. The ether prepared from methylated spirit can easily be brought to ·717 at 60° F. owing to the solution in it of a little methylic ether, a gas at ordinary temperature, but by careful rectification, this can be removed, and a product of pure ethylic ether left. However, for anaesthetic purposes, II. III. & IV. can be used.

I. is not so good, owing to the presence in it of ethyl alcohol and water, but it can be used at a pinch. III. is said to produce more irritation than the others, but I have never seen it do so. V. is only used for commercial purposes as a solvent.

The ether whose effects are mentioned in the following pages are Macfarlan's Anaesthetic Ether (III.) and Tyler's Anaesthetic ether which is IV. The pure methylated ether of a good maker is quite a good agent for anaesthetic purposes.

CHLOROFORM. ($CHCl_3$)

Chloroform as being the more powerful and dangerous agent, has been very thoroughly investigated from a chemical point of view, the more so from the fact, that it was thought that many of the lamentable fatalities from its use, were the result of impurities in the particular sample employed, either from the date of its manufacture or by subsequent decomposition. There are a great many nebulous and hazy ideas among the medical profession about the cause of difficulties, and the "strengths" of the drug, and it is often quite unjustly blamed. Thus I have heard repeatedly, a surgeon irritated by a patient taking long to go under, or coming out too soon, condemn the particular sample used as "useless". On several occasions I have preserved the discarded

specimen, which was used at a later date with no dif-
:ficulty whatever. I had an opportunity lately of
seeing a letter written by an eminent London Anaesthet-
:ist, who was on the staff of one of the large
London Hospitals and therefore presumably
an educated man. He complained that the chloroform
used in his hospital, and which was received from the
manufacturers in gallon stoneware bottles, "lost its
strength", and whereas the first samples taken from
these bottles were all right, he was "unable to
"obtain anaesthesia at all"with the later specimen.
Now, it is difficult to understand how anyone, who
has even a smattering of chemistry, can state that a
definite chemical body "loses its strength". This
gentleman was either using chloroform or he was not
and chloroform cannot lose its strength, without
shewing other signs of decomposition. He also sent
a sample of the dregs of the condemned chloroform,
which was alleged to be "unfit for anaesthetic pur-
":poses, to the manufacturer. I divided this sample
into two parts, one of which I gave to a friend to
use, and the other I used myself. My friend, Dr
Luke, chloroformed a patient throughout a somewhat
prolonged excision of tubercular glands, without
the slightest difficulty or delay; and my half was
used during a radical cure of hernia, and produced

a satisfactory anaesthesia lasting forty-five minutes, with the patient perfectly "under" the whole time. So much for lost strength. Going through the theatres of the hospitals, we see various precautions taken against decomposition. Swathing bottles in black calico, and non-actinic brown bottles, are some of the means used in some wards, while in others, a filthy mess of quicklime is placed in the bottles, which clogs both the stopper and the lint or flannel of the inhaler.

In the following paragraph I purpose to bring some facts which I have obtained, partly from the Pharmaceutical Society discussions, and partly from the published researches of a personal friend, Mr David Brown, F.C.S., who is one of the largest manu-:facturers of chloroform in Britain, and who has made a life study of its chemistry.

CHLOROFORM. ($CHCl_3$) sp.gr. 1·5001. vapour density, taking air as unity, 4·230.

It is manufactured commercially from ethyl alcohol and from methylated spirit. By no means, chemical or physiological, at our command at present can the one be told from the other, as the methyl alcohol takes no part in the chemical reaction during

manufacture. Chloroform prepared from methylated spirit is generally used throughout the large hospitals and in private. A few administrators, mainly owing to prejudice, use the duty paid, so called pure chloroform, prepared from ethylic alcohol.

The first stage of the manufacture gives a chloro-:form of a very low specific gravity, owing to the presence of water and ethylic alcohol. Subsequent rectification raises the specific gravity to 1·4990 at O.C., and this, which consists of pure chloroform with about one-fifth per cent of ethyl alcohol is commercial chloroform. By repeated rectification the specific gravity can be raised to 1·5001 which is chemically pure chloroform. This is an extremely unstable body, and, if exposed to air and light for a very short time, gives evidence of decomposition by fuming, showing the presence of hydrochloric acid and chlorine. This fact of the instability of pure chloroform was discovered by accident in Edinburgh. Two large manufacturing firms used the same methods of manufacture, but the product of one went bad with great rapidity, and batch after batch was returned as too irritating for anaesthetic purposes. On com-:paring notes it was found, that the firm whose pro-:duct was so unsatisfactory, rectified their chloro-:form to a greater extent than the other, and that

they were turning out pure chloroform which was un-
:stable. When a small percentage of ethyl alcohol was added, all trouble ceased. A series of very in-
:structive experiments by M. Jules Regnauld, on this subject, appeared in Pharma. Journal 1884 p. 447.

I.(a) He prepared two samples of chloroform, 1st, by Soubeiran's method (i.e. from chloral hydrate) and 2nd, by the ordinary method. Both were carefully purified and rectified by distillation over sodium in the dark, at 61° C. The specific gravity of each was 1·5001 (i.e. chemically pure chloroform). Por-
:tions of these pure samples were introduced into clean, dry flasks, and were exposed to air and sun-
:light. In two days in June, and five days in Decem-
:ber, evidences of decomposition appeared. A similar result occurred when they were saturated with water. Control flasks kept in the dark but exposed to air, were tested forty times in fifteen months and were found to show no change whatever. No product such as hydrochloric acid, carbonyl chloride or pure chlorine was obtained from the latter, and all their initial properties were retained. These facts prov-
:ed that sunlight caused the decomposition. A flask exposed to daylight for a short time and then kept in the dark also showed signs of decomposition. quickly.

(b). A second series of experiments was devised to show that air also had to do with the decomposition. These proved, that pure chloroform exposed to sunlight in an atmosphere of hydrogen, did not decompose, but shortly after air was admitted decomposition began.

II. The second series was devised to show how decomposition could be prevented.

(a). Portions of the same samples as those already mentioned which underwent decomposition in two days, were placed in flasks and pure ethylic alcohol was added in the proportion of one-tenth, one-fifth, and one-half per cent and were exposed to air and sunlight for fifteen months, during which time they were tested forty times, but in no case was there the slightest trace of decomposition even in the one-tenth per cent sample. Further experiemnts showed that, while methylic and amylic alcohols were very much weaker in their preservative effect, allylic alcohol was as good a preservative as ethylic.

Another interesting proof of the stability of commercial ~~alcohol~~ chloroform was given by Dr Inglis Clark to the Edinburgh Pharmaceutical Society. (Phar. Journal 1882 p.70). A specimen of chloroform which had stood in a clear glass bottle ~~and~~ exposed to diffuse

daylight since the time of the Crimea (i.e.forty years ago) was used to anaesthetise a patient, with perfect success, and no bad results.

Nevertheless in the Lancet 1887 p.240, Dr Newman of Glasgow and Professor Ramsay, stated that chloro-:form should either be used freshly prepared or carbonyl chloride and hydrochloric acid would be present, and gave cases to prove that quicklime pre-:vented this action. They recommended accordingly, that chloroform should be kept over quicklime. The Professor also stated to the Society of Anaesthetists (Trans.Vol.II.p.7 and in his appendix to the B.M.A's Report) that carbonyl chloride is instantly decom-:posed into hyrochloric acid and carbon dioxide. This view was refuted by Brown (P.J. 1898 p.69) who demonstrated experimentally:-

(1). Quicklime did not prevent pure chloroform, sp. gr. 1·5001, decomposing when exposed to air and sunlight.

(2). Chloroform, sp. gr. 1·499, with quicklime decomposed in five days when exposed to air and sunlight.

(3). Chloroform sp. gr. 1·499 similarly exposed without quicklime was not decomposed at the end of several weeks.

Thereby proving that not only quicklime does not prevent, but actually hastens decomposition.

It may be interesting to note in conclusion, that I have been able to obtain the chloroform used in two fatal cases which I have witnessed, and that used in several narrow escapes, for the purposes of analysis, and in every case the sample was a pure commercial chloroform of sp. gr. 1·499.

Professor Ramsay obtained specimens, from various investigators for the purpose of analysis in the B.M.A. investigation, but in no case did he find any fault chemically with them, ~~[illegible]~~ so he took the somewhat extraordinary method of trying to produce decomposition in a sample of his own and then dilating upon the products of such decomposition.

The conclusions we must come to are:-

(1). Pure chloroform sp. gr. 1·5001 is useless for practical purposes owing to its instability.

(2). Chloroform supplied by good makers is comparatively stable; although there is no necessity for exposing it to light more than can be helped, yet it need not be kept in absolute darkness.

(3). The impurities which occur in decomposed chloroform are such as to make it extremely irritating and irrespirable, and not those which would produce sudden death.

PHYSIOLOGY OF ANAESTHETICS.

Chloroform and Ether.

An account of the endless discussions and differ-:ences concerning the physiological action of anaes-:thetics is quite beyond the scope of this paper, which is practical. I propose to give the baldest account of a few of the less controversial points.

I. Nervous System. Most physiologists hold that chloroform and ether first stimulate, and then depress the nervous system, and that this depression begins with the higher centre, and passing downward through the lower intracranial centres, then affect-:ing the spinal cord and lastly the medullary centres causing death. It is also agreed that the sensory and receptive functions are affected slightly be-:fore the motor ones. According to Cushny however (Pharmacology p.153) it is possible that the motor cells are not directly paralysed by the drugs, but are unable to send out impulses without receiving them from the paralysed sensory system, and that the paralysis of the latter is thus the cause of asphyxia

and death. The theory advocated by Schmedeberg and his followers cannot be passed over. This authority believes that the action of anaesthetics, like that of alcohol, does not cause stimulation at all, but in all cases, a gradually descending depression, be-:ginning with the last educated and most highly specialised centres, such as those of self control &c. He explains the initial singing, shouting, brilliancy of speech, &c. observed in commencing intoxication as due to the depression of the normally acting inhibitory centres of each individual. We know the different temperaments of different individuals, how one is easily excited while another is phlegmatic and difficult to affect. To use a simile which will go a long way to explain the theory, the followers of Schmedeberg seem to me to consider an average in-:dividual somewhat like a bicycle going down hill with a brake applied. There are two ways in which speed may be increased, firstly, by pedalling, i.e. stimulation; secondly, by removing the brake i.e. paralysis of inhibition. It is not my intention to apply this theory to anaesthesia, but we have in this theory a more efficient explanation of a fact often observed, namely that a patient in a state of profound collapse, is often very much the better of being anaesthetised for operation, and that this

improvement lasts far longer than it would, if the anaesthetic first stimulated and then depressed. A collapsed and moribund patient when anaesthetised often improves in pulse and respiration when under the influence of chloroform, but more so with ether, now if the action was a stimulation during the second stage of the anaesthesia followed by depression, it is obvious, that the patient would be as bad as before if not worse when anaesthesia was produced. Whereas if we consider shock to be a state of pro-:found inhibition, then the continuous depression of the inhibiting centres would explain the improve-:ment. The marked excitement produced by ether is explained by the irritant action of the vapour on the mucous surfaces while the body is in a state of anarchy being freed from higher control.

II. Respiratory System.

There is a tendency at first to hold the breath owing to the irritant qualities of the vapours. This is, of course more marked with ether than chloroform. We cannot compare man with the lower animals here, for there are a large number of modifying influences, chief among which are the pschycical elements of fear of approaching operation, or nervousness owing to surroundings, which render comparison with lower animals in the initial stages

of anaesthesia impossible. We cannot say therefore what is due to action on the respiratory centre of the already absorbed drug, what is due to fright acting in a consciousness which is beginning to be in abeyance, and what is due to local irritation. The respiratory phenomena depend on the strength of the vapour, for as Claude Bernard and the Committee of the Royal Medical Chirurgical Society pointed out, chloroform if given as a very concentrated vapour, produced asphyxial symptoms at once. The action produced by holding the breath, is next complicated by the struggling of the second stage, which, speaking generally, causes alternately some degree of asphyxia and deep breathing. After the respiration becomes quiet again and regular owing to these disturbing elements passing off, for as the reflexes become dulled the irritant effect of the vapour has no effect. In Dastre's publication (Sco. Anaesthesiques) Paul Bert shows that costal breathing is paralysed before diaphragmatic and Dastre himself mentions that a comparatively small weight on the thorax quickly produces death, even although the drug be not pushed. (This is a practical lesson to avoid the slightest weight on the chest of a patient during operation, a thing that is sometimes apt to be forgotten, as frequently assistants ~~are apt to~~ lean their elbows on

the thorax of a patient when the operation is about the upper part of the trunk). He also considered that expiration was sooner affected than inspiration. Another and important cause affecting the respira-:tion, in chloroform at least, is the lowering of blood pressure which occurs. Here it may be men-:tioned that, from a practical point of view, the attempt to separate the circulatory from the respir-:atory systems while discussing anaesthetics seems, to one who is not a physiologist, most extraordinary. In health, in disease, anatomically and pathological-:ly, the action of the heart and lungs seem to be as mutually dependent on each other as the boiler and engines of a steamer, and if anything affects the respiratory system, it may be inferred, that the heart's action will almost immediately be modified. An important point bearing on practical anaesthesia was pointed out by Hill (Journal of Physiology Paper I.) who pointed out the fact, that immediately the head of an animal under the influence of chloro-:form to the point of death, is lowered and there-:fore the blood pressure to the respiratory centre increased, respiration recommences. if stopped, or becomes more powerful if weak, and this occurs al-:though the increased blood supply to the centre is bringing up fresh quantities of chloroform.

This lowering of the head is one of the most valu-:able means of resuscitation we have in cases of trouble.

III. Circulatory System.

The action of chloroform on the cir-:culation has given rise to some of the keenest controversies in the history of medicine. The ques-:tion as to whether chloroform has, or has not, a direct action on the heart is not yet settled to the satisfaction of all, although the bulk of evidence is in favour of those who maintain, that it has a direct paralysing action on the heart.

Syme and the Edinburgh School of Surgeons main-tained, that if the respiration was going on all right, the heart could be left to take care of itself. This is true in the vast majority of cases, but in no way proves that the heart is not being seriously weakened during a prolonged administration. Failure of respiration is so immediatley followed by that of the heart (under chloroform not under ether) that practically, it does not matter one whit whether the heart gives a few contractions after the cessa-:tion of respiration. The important point is, Can the heart's action be restored? The first scientific investigator into the subject, Snow, believed that

chloroform acted as a distinct depressant on the heart, and that death took place from cardiac paralysis due to too concentrated vapour being inhaled, and that if given in a state of sufficient dilution no such danger would occur. This is the view of the dosimetric school of anaesthetists. Snow was a practical anaesthetist and administered chloroform in 5000 cases without a fatal accident. His principle was a definite quantity of chloroform to a definite quantity of air, and the strength of the inhaled vapour must never exceed four per cent. The Glasgow Committee of the B.M.A. made a large number of ex-:periemnts and reported, that there was a steady fall of blood pressure during the administration of chloroform, ~~and~~ that this was partially due to the depressant action on the heart, and that the re-:spiratory paralysis was due, partly to the lowered blood pressure and partly ~~due~~ to the action of the anaesthetic on the nervous mechanism of respiration. (Brit.Med.Journal 1880, 18th Dec.)

The two Hyderabad Commissions published their Report in 1890, and their view was, that the fall of blood pressure which occurs was due "solely to "narcosis of the vaso motor centre and if not a "safeguard against overdose is absolutely harmless". (Report p.137). Thus vindicating the teaching of

Syme, at least in so far as experiments on animals can be compared with clinical experience. A large number of workers such as Professor Gaskell, Shore, McWilliam, and Leonard Hill, criticised the work of the Commissions, and declared that their conclu-:sions were wrongly drawn from the evidence, and that their methods were faulty. While admitting that respiration usually fails before the heart Gaskell and Shore (B.M.J.1893 p.227) denied that the heart was unaffected and maintained that death took place:-

(1). By weakening of respiration causing insufficient aeration of the blood which in its turn causes heart failure by the combined action of chloroform and asphyxia.

(2). By weakening the heart, due to insufficient blood pressure, which in its turn causes cessation of respiration through the combination of chloroform and insuffi-:cient blood supply.

In both cases the chloroform affects both the heart and the respiration, and in both the respiration stops first but (1) is a case of death from respir-:atory failure primarily, and (2) is a case of death from heart failure mainly. The missing link necessary to complete the chain of evidence against

chloroform as a depressant of the heart was suppli-
:ed by McWilliam (Practitioner vol.XXVI. p.436)
who found that from the time that the corneal re-
-flex was lost there is a varying degree of cardiac
dilatation. This dilatation which may be sudden,
was quite independent of the rate of the heart's
action. He further found that this cardiac dila-
tation was not due to increased pulmonary resistance,
but was due to the action of the drug on the cardiac
mechanism itself. In some cases it occurred after
the administration commenced and after it could be
dispelled by ether. While agreeing with the Hydera-
:bad Commission that the characteristic fall of
blood pressure was partly due to depression of the
vaso motor centre, he yet maintained that the cardiac
dilatation was the chief factor. Usually dilatation
did not occur until the fall of blood pressure had
taken place, but this was not always the case.
Leonard Hill corroborated McWilliam's views (B.M.J.
1887 p.1496) and pointed out that the important
point is, not when the heart actually stops, but when
it ceases to act as an efficient blood pump. Often
the heart is making impotent efforts at contrac-
:tion long after circulation is at a standstill.
To sum up according to Hewitt (Op.Cit. p.91) "It
"may be regarded as established that during chloro-
":form anaesthesia, the anaesthetic directly produces

"a depressant action on the heart itself; and that "while it is true that not only in the physiological "laboratory but also in actual practice, that respira-":tion generally fails before , yet it is the want "of cardiac action which is the essential in the "causation of death under chloroform."

It will be observed on going through some of the literature on the subject that all observers, Snow, Hewitt, Leonard Hill, Cushny, Clover, and Gaskell emphasise the danger of concentrated vapour, and maintain that the interval between the cessa-:tion of respiration and cardiac arrest is commonly proportionate to the strength of the vapour.

According to most physiologists ether produces a stimulating effect on the circulation and ~~that~~ this stimulant action is kept up, even after anaes-:thesia is produced, and ~~that~~ the concentration of ether vapour to produce cardiac depression is ever so much greater than that of chloroform, being 30 to 40 per cent, as compared with five per cent of the latter.

I do not propose to enter into the effect of the various agents on the tissues which is a sub-:ject at present under investigation. There is one point however of practical importance. Ether vapour acts as a powerful glandular stimulant and

accordingly a troublesome pouring out of saliva and mucus occurs during its inhalation. Occasionally also there is some action on the kidneys by which a temporary albuminuria or even ~~the presence of~~ blood may be found in the urine after ether administration.

FACTORS BEARING ON ANAESTHESIA.

Before discussing the clinical aspects of the various agents, there are several factors which must be considered.

(1). Man must be placed on a plane apart from the lower animals, as anyone who studies the literature of the subject, and has practical experience, quickly finds out. How can comparison be made between a dog tied up and poisoned with chloroform, and the miserable nervous patient who has lain awake for nights thinking of his coming operation, and who is subjected to the additional depression of a drastic purge and semi-starvation for several hours?

(2). The personal equation of the patient has a great deal to do with the effects of the anaesthetic. The nervous patient who is wheeled into the theatre "goose skinned" with fear, whose tremors shake the operating table, who is in a cold perspira-
:tion (I am of course describing an extreme case of

which I have witnessed many) and whose fluttering breathing seems to be about to make the production of anaesthesia an affair of hours. Are we to compare the vitality of such a patient with the soldier who tells the surgeon to "go it", and goes under the anaesthetic shouting "Camerons to the front" as was recently seen in an Edinburgh Hospital. On the other hand when we look at the records of fatal cases we are met with the extraordinary fact that in a large proportion ~~of fatal cases~~ the patients are strong and healthy and die suddenly whereas the collapsed and almost moribund patient is wheeled back to bed in better condition than he was before the operation. Is this the mysterious entity known as idiosyncrasy or does the strong healthy man get an overdose on the top of his struggles.

(3). Surroundings, temperature, locality, race, and climate, all must be taken into account. Take chloroform for instance. Laurie of Hyderabad gives 45,000 cases of chloroform administration without a fatality. The patients were mainly Asiatics, with all the indifference to surroundings, and fatalism of eastern races, anaesthetised in a hot climate, many of them vegetarians, non-alcoholic, and accustomed to simple life. We cannot argue from that the safety of chloroform or attempt to equal that record

with the worn out, drink sodden, poverty stricken patients we often see in large hospitals in this country.

Temperature is of some importance also. Snow made a series of observations on the amount of chloroform vapour taken up by air at various temperatures and found that the percentage of chloroform breathed from a handkerchief varied greatly with the temperature, double the percentage being breathed at 60°F. than at 10°(Op.cit.p.34). B.W.Richardson (Hospital 1894 p.481) found that animals chloroformed at 40°F. anaesthesia was accompanied by a good deal of excitement and vomiting whereas at 80°the same animals went under quietly and rapidly. In this connection I remember a discussion which I had with a fellow resident. We compared notes as to effects of chloroform and he seemed to have much more sickness and a larger proportion of troublesome cases than I had. The methods of administration were the same in both theatres, students administered under the superintendance of the junior house surgeon, and we often wondered what factor caused the difference. It has struck me since reading Dr Richardson's article that a possible explanation was the size of the operating theatres. The patients under my charge were chloroformed in a small theatre which was kept at a much

higher temperature than that of my friend which was a large theatre capable of seating several hundred students. Mode of life and condition of patients modify effects. Alcoholic, plethoric, obese, Falstaff-:ian subjects are notoriously troublesome subjects. An interesting fact shewing the effect of the mode of life has been shewn in the South African War. During surgical manipulations at the front owing to convenience chloroform has, par excellence, been the anaesthetic used. Professor Chiene informed me on his return that he did not remember a single case in which there was any trouble with the anaesthetic. As I was interested in all points appertaining to anaesthetics I questioned fourteen civil surgeons whom I have met; not one had seen any death under chloroform and their experience was similar to Professor Chiene's. No death from an anaesthetic has been reported. The cause of this pleasing state of affairs is an inter-:esting speculation. It might be suggested that the patients were men in the prime of health and strength. The reply is that it is the strong men who often die suddenly under chloroform. Professor Chiene himself thought that the enthusiastic courage of the soldier on active service was the reason (compare with Dr Laurie's Asiatic fatalists) and I have no doubt this fact coupled with short rations, abundance of air and

light and abstinence from alcohol are among the reas-
:ons of this immunity from danger. An individual's
intestinal tract is bound to be in a less septic con-
:dition when he is on short commons than when he
is eating twice as much as nature requires and there-
fore the depressing auto-intoxication from a chronic-
:ally loaded colon will be far less.

(4). Is there a "moriturus"? An individual who is apparently healthy and yet whose vital processes are so delicately balanced that the administration of an anaesthetic causes immediate death. This un-
:fortunate individual has been much discussed but it is a significant fact that he never has nitrous oxide or ether administered to him, by any chance, but always chloroform. A glance over the fatalities of the two latter anaesthetics shews the fact that the hopelessly sudden death which usually occurs in a chloroform fatality is absent and that the fatal issue has been much more gradual. If we admit the "moriturus" we must allow that he never gets any-
:thing but chloroform.

(5). <u>The Operation</u>.

This of course has obviously much to do with the safety of the patient. One cannot have much clinical experience or read the clinical reports

reports of the two commissions without noticing that trouble with the anaesthetic occurs far more frequent-:ly in some operations than in others. I will indi-:cate seriatim several of the operations in the order of the number of accidents in the Lancet Commission's report. Dental Operations, (there is such an appalling-:ly high death rate in dental operations that I will afterwards discuss this class of operation by itself): Reduction of dislocations (this class of operation is second no doubt owing to the agent being pushed to produce muscular flaccidity): operation for empyema, rectal operations, operations involving forcible dil-:atation of sphincters, excision of the eyeball, castration, abdominal operations, were all specially mentioned as those in which a higher anaesthetic death rate occurred than usual.

(6). Age.

No age is exempt from accidents. Speak-:ing generally in youth and old age anaesthesia is better borne than in middle life. Children as a rule take chloroform well yet are not exempt from accidents. With ether it is more difficult to speak as the irritability of the air passages in the young, and the brittle arteries of the old render chloroform perhaps a better anaesthetic in the extremes

of life. I have frequently used the chloroform ether sequence in children who were worn out with disease, with remarkable benefit.

(7). Sex.

Both the Lancet and the B.M.A.Clinical Com-:missions state that fatalities and difficulties are less prone to occur with women than with men. The latter part of this statement is also my own experience with chloroform, but with ether the large preponder-:ance of females to whom I have administered the latter renders comparison difficult.

(8). Posture.

It is an extremely unfortunate thing that in the reports of neither of the two commissions is any stress laid on posture, as a factor in produc-:ing difficulty. Over and over again in my own cases I have noticed that slight modifications in posture make all the difference between the safe and the unsafe, the difficult and the easy. Especially about the position of the head and neck a slight change of posture produces profound results out of all propor-:tion to the simplicity of the modification. In several cases hampering of patient's breathing by the surgeon or assistants unconsciously leaning on the patient's thorax, letting his arms hang down, piles

of heavy instruments lying on his chest, have been to blame. The prone or semi-prone position which is very convenient and safe with ether seems not to be so in chloroform. I have notes of seven narrow escapes from death, and one death, in all of which the patient was lying partly on his face. I also remember a large proportion of the cases in which the operation had temporarily to be stopped owing to difficulties with the anaesthetic, were in patients in this position.

When ether is given in the supine position there is often much less trouble from mucus getting in the air passages if the head is slightly turned to one side. Another personal experience is that the ex-:cessive movement of the abdominal wall which the deep respiration of ether occasionally causes, and which annoys the surgeon in an abdominal operation, is less marked if the patient is placed in Trendelenburg's position. Patients who are worn out by disease or in a state of shock also do better in this position than in the horizontal one. The sitting posture is unanimously condemned for chloroform administra-:tion and should never be used. Its use is undoubt-:edly the cause of a considerable proportion of the deaths in dental operations as this is the best posture for such operations. Nitrous oxide and ether

either alone or in sequence may be given in this posture with perfect convenience and safety.

(9). Methods of Administration.

This will be discussed at a later stage.

(10). Preparation of Patient.

As House Surgeon in several hospitals, I have had good opportunities of observing the effects of different methods of preparation for operation and this will be somewhat more fully discussed than any of the other factors. The usual plan of preparation for operation subject to such modifications as the state of the patient, operation, emergency or otherwise, is, several days in hospital before operation, regulation of diet with clearance of bowels in the day (often at night) previous to the operation with calomel or Henry's solution, or castor oil in the case of children, no solid food on the morning of operation except assuming the operation is to take place about 11 a.m. the patient has weak tea and a slice of toast about 6 a.m. Now we must remember that this is not preparation for operation but preparation for anaesthesia. Apart from the tendency to vomit during anaesthesia it is not preparation for a day's work, this purging and starvation, far less for an ordeal which calls for

every bit of vitality. In the first place every resident and staff nurse is familiar with the nausea and depression produced in a number of individuals by calomel and Henry's solution. I strongly maintain that the purgation should in no case (of course when there is no immediate hurry) take place later than forty-eight hours before the operation. Apart altogether from the sinking feeling produced by catharsis it cannot be good for a patient to be making peregrinations to the turret several times in the night, of all others, in which he requires a good night's rest. Empty the rectum by enema on the morning of operation by all means but let the systematic clearing out of the bowels be done a day or two before the operation. Dr Hewitt (Op.cit.p.198) states that he is satisfied that on many occasions the excessive use of powerful purgatives just before operation produced extreme depression during administration. Secondly the starving of the patient on the morning of operation undoubtedly causes depression. Now of course it is impossible to give solid food just before anaesthesia, as not only is the vomiting disgusting, but it exposes the patient to the risk of foreign matter entering the larynx. An interesting paper was read before the Royal Medical Society by Dr Ross, a fellow student of my own, who

pointed out that emergency patients, picked up off the street and whose stomachs often contained quantities of food, although they often vomited on the table, this sickness was extremely transient and prolonged sickness afterwards seldom occurred. I took note of this paper and carefully watched a series of emergency operations. Out of twenty-five such operations the after course of which I had opportunities of watch-:ing, sixteen had had food within three hours of their operation, thirteen of these vomited once or twice on the table but only two vomited at a later period than three hours after the operation. I am aware that these few cases prove nothing but the ~~evidence of~~ residents and staff nurses, who have the charge of the patients after operations, almost unanimously think that there is less after sickness in these cases than in the more carefully prepared ones. Another fact that has convinced me of the truth of this is that some of my worst difficulties have been in patients whose operation has been post-:poned for twenty-four hours and have had to be pre-:pared a second time. This is I believe a common experience in such cases. Now I would not for a moment suggest a solid meal but I strongly think that some highly concentrated food should be given at a much later hour than is customary. (Since writing

the above I have learned that in one of the largest surgical departments of the Royal Infirmary there has recently been introduced a plan of giving patients a warm cup of tea made with milk along with prepared plasmon at 8 a.m. instead of at 5.30 a.m. which was the rule before, and that the change has been attend-:ed with quite satisfactory results, and ~~often~~ shock and depression in severe operations have been much lessened). In very depressed patients a warm enema of peptonised white of egg with coffee just before operation is often of great benefit. Alcohol may also be given by the mouth in such cases, and also the hypodermic exhibition of strychnia. Morphia is occasionally given before operation but its use is open to some degree of deprecation. It is usually given in operations about the mouth and tongue to prolong the anaesthesia and to lessen the interrup-:tion by the patient coming out. As I will after-:wards shew there is a method of administration in such operations so convenient that morphia is not required. The disadvantages of morphia are two fold, firstly, its use is antagonistic to the suc-:cess of methods of resuscitation should any danger occur, and secondly, it certainly tends to increase after sickness. The exhibition of morphia after operation is often extremely beneficial.

CLINICAL PHYSIOLOGY OF ANAESTHETICS.

NITROUS OXIDE.

This agent being a gas, the various stages follow each other so quickly owing to its diffusibil-:ity, that it is hard to draw the line between them.

1st Stage. This varies greatly with individuals and surroundings. The remembrance of it afterwards is a terrible nightmare to some patients, while to others it is a pleasant dream. The first sensation is a feeling of warmth and general tingling through-:out the body with a desire for more air and an irre-sistible tendency to take long breaths. Loss of consciousness often comes on so quickly that nothing is remembered after the application of the face piece. The pulse quickens and becomes fuller. To-:wards the end of this stage cyanosis begins to appear. After twenty to thirty seconds the patient passes into the second stage.

2nd Stage. Cyanosis deepens and the air hunger increases. Movements which may be co-ordinate or incoordinate take place. Trade movements such as treadling of a sewing machine, polishing, typewriting often occur. Any undue interference with the patient at or before this time has a tendency to increase these movements. Also an important practical point

is that if any painful operative procedure is adopted during this stage, it is felt by the patient and as the feeling is distorted and intensified this gives rise to the terrible dreams which haunt many patients to such a degree that ~~they~~ he, at a subsequent period, would rather face the pain of an operation without any anaesthetic than undergo such an ordeal a second time. The pupils are large and the conjunctiva is usually quite sensitive.

3rd Stage. The Cyanosis deepens, the pupils become widely dilated, respiration becomes sterterous and this with the insensibility of the conjunctiva is an indication that the patient is "under". This stertor however varies greatly with the amount of extension of the head. The pulse rate often runs up to 110 - 140. There is as a rule complete muscular flaccidity but this does not always occur. Minor operations can now be performed without any pain as a rule. Very occasionally patients lose neither their consciousness nor their rigidity however far the gas is pushed, but this is somewhat rare. Clonic movements are frequent and very occasionally tonic contractions also may occur. I have witnessed two cases of the latter in one of which a complete opisthotonos was produced, the patient resting on his head and his heels and also having the risus

sardonicus. This almost immediately passed off how-:ever. The time taken to produce this stage varies in my experience from 45 to 65 seconds. Dr Hewitt (Anaesthetics p.217) by counting the respirations found in sixty cases that the average number of respirations to produce deep anaesthesia was about 29. The lowest being 6 and the highest 72. As will afterwards be mentioned under the head of dental operations there are other drawbacks than the patient's feelings in commencing the operation too soon. The available anaesthesia is about 28 seconds and during this time whitlows, abscesses &c. may be opened, and in an easy case as many as six teeth may be extracted. I will afterwards describe under the heads of methods of administration and sequences, methods of prolonging this available anaesthesia. Recovery takes place in 20 - 30 seconds and the patient generally is able to walk within a minute of the removal of the face piece.

ETHER.

The effects of the inhalation of ether vapour vary to a great extent with the method of administration, far more so than with the patient. Indeed the influence of method is so marked that the phenomena of the first two stages when a closed

inhaler is used are quite different from those in which an open method is used. This influence of air supply, or concentration indeed are all important, and it is safe to say that if the excellent and ingenious ether inhalers now on the market had been invented fifty years ago probably Professor Simpson would never had the same cause for the investigations which culminated in the discovery of chloroform, as now at least in temperate climates, ether is for most operations quite as convenient and a great deal safer than chloroform.

1st Stage. When ether is administered by a good method and by an experienced person the first stage, and the second, are as far as external evidence goes extremely slightly marked and the first audible sign is the stertor which betokens the patient being "under". The first sign after the inhalation is com-:menced is repeated swallowing, owing to the saliva which is poured out owing to the local action of the drug. There is, if the vapour be too strong a tend-:ency to holding the breath and coughing, and a feel-:ing of suffocation sometimes causes the patient to clutch wildly at the inhaler: some patients are so sensitive to this suffocative feeling that they cannot remain still, and this is where the advantage of the gas ether sequence to be afterwards described

comes in. As a rule however, coughing and holding the breath mean too strong vapour.

2nd Stage. This stage also varies to a great extent with method. Thus, if ether be given by the open method by being poured ad lib. on a towel we have a very much more marked stage of excitement than with chloroform, whereas, if it is given in a closed inhaler the excited stage is usually very much less than that of chloroform. I had occasion to administer ether to a man of very powerful physique who had just returned from South Africa. Before taking his place on the operating table he warned the bystanders in general, and me in particu-:lar to be very careful to hold him as he had recent-:ly had chloroform administered to him, and, while in the first stages, injured the administrator with his fists, and it had taken the united efforts of three men to hold him. As ether is far more of an intoxicant than chloroform I had a considerable degree of trepidation in starting the inhalation with this patient and accordingly considerably pro-:longed the re-breathing into the bag of the Clover's inhaler, while very gradually turning on the ether cylinder, so as to restrict the air supply somewhat and somewhat increase the asphyxial element. By taking this precaution the patient was passed into a

quiet anaesthesia without any excitement at all ex-
:cepting a momentary rigidity. When this passed off
I was enabled to give him a full air supply again with
the ether full on, and throughout the rest of the
administration no difficulty of any kind supervened.
This is but a single instance of the fact that when
carefully administered ether produces less excite-
:ment than chloroform. Just as during the first stages
of chloroform administration however, any undue
interference with the patient such as moving him
about, taking off bandages, scrubbing his skin, &c.
tends to increase and prolong the stage of excite-
:ment. Some of the troubles which may arise in the
second stage are:-

(1). Excessive secretion of mucus and saliva.
The patient's pharynx fills with a very sticky and
tenacious secretion which is very troublesome to
get rid of, blocking the air passages and often
causing coughing which may stop the administration.

(2). Coughing. This is a very troublesome
complication and is most frequently caused by too
strong a vapour raised by a too quick turning up
the cylinder in the inhaler or by some of the sticky
saliva being drawn into the larynx.

(3). Spasms of the glottis. This sometimes
occurs in the second stage and may give trouble. It

is quite different from that which sometimes occurs in the third stage. It is usually preceded by crowing inspitations and is usually produced by too strong vapours, mucus passing into the larynx, or manipulation. It is complicated by spasm of the muscles affecting the respiratory passages such as the muscles surrounding the pharynx, &c. Horsley and Semon found that ether had a differential action on the abductors as compared with the adductors of the vocal cords, the abductors losing their excitability long before the adductors. They offered no explanation but this fact may explain the cause of larynxal spasm under ether which is certainly commoner than under chloroform. (Brit.Med.Journal 1886 p. 405) Another laryngologist Dr Hooper of Boston found that whilst stimulation of the recurrent laryngeal nerve in light ether anaesthesia produced adduction yet in deep anaesthesia it produced abduction. (Trans.Amer.Laryng.Soc.Vol.VII.). Other phenomena of the second stage are a bounding pulse of over 100 per minute, a flushed and often slightly cyanosed face, a free perspiration, dilated pupils and capillaries. During the second stage the troublesome phenomenon known as "ether tremor" may set in. This is a fine rythmical tremor which shakes patient and table and is extremely annoying to the surgeon. The

movement is like a fine ankle clonus and is general throughout the body. I have only observed it once in the case of a lad of 22 in whom it came on in the second stage and lasted throughout the whole of an operation for appendicitis and was at times so marked as to seriously interfere with the operation. Aacord-:ing to Professor Guillard it never occurs in women and only in alcoholic or neurotic men. Dr Hewitt has observed it in young and non-alcoholic subjects (males) between 20 and 30 years of age (op.cit.p.289). My own case was 22 years of age, was a nervous lad but a total abstainer. I am not prepared to offer any explanation of its occurrence but it seems to be rare at least in this country. As the administration proceeds the respirations become deeper and less irregular (this change often occurs suddenly) and the patient quickly passes into the third stage.

3rd Stage. There is complete muscular relaxa-:tion with the characteristic sterterous breathing due to the relaxing of the fibro-muscular tissues surrounding the air passages. There are often moist coarse râles owing to the free secretion of mucus and saliva into the pharynx. The breathing is deep and regular. The pupils which have hitherto been somewhat widely dilated become only moderately so

and in rare cases contracted. The corneal reflex is abolished. Another form of closure of the larynx often occurs. This produces a sound during inspira-:tion which resembles nothing so much as the sharp clicking sound of the aortic valve stretching in a much exaggerated degree. It gives one the idea of the inspirating air current being suddenly cut off by a thin fibrous flap which closes with a flap like that produced by the sudden stretching of wet linen. It is of no clinical importance and may be stopped by a slight change of the position of the patient's head such as slight flexion on the chest. As far as my own observations are concerned I have never seen it during administration of chloroform or gas. I think that the cause is the sticky mucus acting somewhat as a ball valve. The circulation is very unlike that in the third stage of chloroform narcosis. The pulse is extremely full and bounding from first to last even during a prolonged operation. It is usually from 15 to 25 beats per minute faster than normal, its characters are those of a high pressure pulse. According to Hewitt by the use of a sphyg-:mometer it will be found that there is but little fall of blood pressure during a prolonged operation. This is the stage in which the patient ought to re-:main during the operation. It may be noticed that

no mention has been made of vomiting which so often gives trouble during chloroform administration. As far as my own experience goes there is far less retching with ether than with chloroform during the actual administration & this is so even if the patient is allowed to occasionally come out. After the administration is over there is often a sharp fit of retching but during the actual administra-:tion I have had much less sickness than with chloro-:form at least when the latter was administered on a towel.

4th Stage. With a healthy adult it is almost impossible to give an overdose of ether if there is plenty of air passing into the lungs. When the bag is off a Clover's inhaler and the indicator at "full" i.e. all the inspired air passing through the ether chamber, a patient may be steadily kept under by recharging the receiver occasionally with fresh ether. This immunity from overdose is no doubt owing to the rapid circulation and the quick elimina-:tion of the drug making a toxic accumulation diffi-:cult. Should the patient be weak or the bag used too much, an overdose is possible and the sign of this is gradual failure of respiration, great cyanosis, dilated pupils, accumulation of mucus in

the trachea and bronchi, a condition reminding one of the death rattle. That the patient is getting into a dangerous state is apparent to the veriest tyro and it is owing to this early hoisting of the danger flag that ether owes its safety. If the pulse be examined even when the patient is getting into this alarming state it will often be found to be surprisingly good considering the apparently dangerous state of the patient. Of course owing to the intimate relations between respiration and circulation already mentioned it may be diminished in speed and force but not so much as would be expected. This leeway gives us a much wider scope for the applying of restorative measures.

Circulatory failure under ether occurs very occasionally in patients who are in a state of profound collapse or whose vitality is from any cause extremely low. This is borne out by the records of many of the fatalities. I have never seen any pallor or other sign of syncope during ether administration even in the rare cases in which vomiting has taken place on the table.

CHLOROFORM.

The clinical features of Chloroform in many ways resemble those of ether. Several fundamental differences however have been, and will be duly mentioned. The various phenomena although they depend to a certain extent on the method of administration do not do so nearly to the same degree as with ether, on the other hand idiosyncrasy seems to come into play to a greater extent with chloroform. I propose to keep up a running comparison between the two both here and afterwards while discussing administration.

First Stage. As the vapour of chloroform is to most individuals much more pleasant to inhale than that of ether one would naturally expect much less choking, swallowing of saliva, holding of the breath, sense of impending suffocation during its initial stages, and this is the case. Here again as with ether coughing means too strong a vapour, but is much less common than with ether. There is the same sense of warmth, confusion of ideas and from the very first breath or two there is some analgesia. This property is valuable practically in medicine for the relief of the agony of biliary and of renal colic, and the labour pains of midwifery. It is too dangerous and insiduous a drug to be placed indiscriminately in the hands of the laity for these purposes but it is

very useful when so administered by a qualified per-
:son. The use of chloroform for the relief if neur-
:algic pain was brought to my notice by a personal
experience. While attending a gynaecological clinique
recently in which the patient was under chloroform
my attention was distracted from what was going on
by a severe toothache from an exposed pulp which
became so painful that I rose to leave the room.
While passing the anaesthetist I obtained the towel
for a few moments and determined to get a few seconds
respite from the pain at any cost, I took several
long breaths of chloroform vapour. The usual giddi-
:ness and vertigo of the first stage immediately set
in and immediately the pain became dulled, and as
the effects of the drug passed off the pain gradu-
:ally disappeared and, to my surprise did not come
back for nearly twelve hours although before this I
had been having attacks every hour or two. I do
not think that the action was a local one as the
inhalation was through the nose, but evidently some
alteration in the local circulation was produced.
This analgesic effect is produced by the accoucheur
during the acme of a labour pain and saves a great
deal of suffering.

Second Stage. Here as with ether when given by
the open method there is frequently muscular contraction

with tonic contractions which vary greatly with differ-
:ent patients. Alcoholic patients especially are troublesome during the second stage. Singing, shout-
:ing, praying and swearing may all occur in various patients often in a manner totally irrespective of the usual mode of thought in the particular patient. (If this view be not accepted then chloroform must be a good unmasker of hypocrisy). But there is one point which must be emphasised as it is of supreme practical importance. This is the fact that whereas with ether we can regard struggling and excitement when it occurs with a great deal of equanimity, and look on tonic spasm as a nuisance rather than as a danger and can hold the facepiece firm and push the administration, it is not so with chloroform. A very large proportion of fatalities occur after struggling and at no period of the administration so should our anxiety be greater than during or after a fit of struggling. It is here that the folded towel with the concentrated vapour is dangerous. The right heart is overloaded by semi-asphyxia and muscular action, the respiration is in abeyance owing to muscular spasm, no excretion of the chloroform vapour is taking place, the vapour in the air passages is being absorbed. We have then an impeded pulmonary circulation, the heart overpowered and an undue pro-
:portion of chloroform in the blood, when suddenly

the spasm passes off a deep sighing respiration in-
:itiated by the venosity of the blood, there is a
saturated towel over the face in the hollow of which
owing to the absence of breathing, a concentrated
vapour has gathered. A large quantity of this is
accordingly drawn into the lungs almost instantaneous-
:ly the last straw is added and the already over-
:burdened heart ceases its action. This occurs again
and again in the list of fatal cases published in
the B.M.A. and the Lancet Reports. Struggling and
gasping are mentioned as the preliminaries. If the
cloth or other means of administration be removed
until quiet respiration is resumed this danger is at
once lessened, and on its replacement the patient
passes quietly into the third stage. Again, and this
is true of all anaesthetics, all noise, conversation,
slamming of doors, lecturing, moving of tables and
furniture, and pulling about of the patient should
be rigorously tabooed as this tends to increase the
excitement stage. It is a well known fact that the
secret drinker is not nearly so apt to become noisy
and hilarious as one who drinks to excess in company.
This is analagous to the patient chloroformed in a
quiet and shaded room and one amidst the too fre-
:quently noisy surroundings in an hospital. For the
same reason when a patient tends to struggle and it

is necessary to restrain his movements somewhat, to prevent him injuring himself or his neighbours, such interference should always take the shape of guidance of his movements and passive resistance, and never that of forcibly holding him down. When the excite-:ment passes off, the patient passes into the third stage, but before discussing this stage we must con-:sider several exceptions to this, which is perhaps the usual type.

(a). Some patients and more especially children, have little or no excitement stage but lie like a log, breathing softly, with slightly contracted pupils and often sensitive conjunctivae. To the inexperienced eye the patient is fully under, a nod is given to the surgeon and the incision is made, instantly the patient struggles violently, taking the bystanders all their time to restrain him. Now the danger here is not cardiac inhibition which is not so prone to occur in a young person, but lies in the fact that frequently the anaesthetist is often a man very much junior in standing to the operating surgeon and being in an apologetic frame of mind and covered with confusion from the reproachful glance of his chief, he pours on a large quantity of chloroform and as the patient is now taking long

breaths an overdose is given. In my first days of o office as junior house surgeon this occurred to me on several occasions until experience taught me that it is frequently impossible to say whether or not a child is under. The moral is, if such a patient is thought to be under let the operation commence but beware of the struggling as before.

(b). Another type of troublesome patient is the patient who begins breathing in a shallow manner and never seems to improve on it. This shallow breathing is often associated with a pale face, a clammy skin, and a tendency to vomit, and is I think most frequent in the female of bilious tempera-:ment. A very usual exciting cause of this condi-:tion is a timid and irresolute method of starting the administration. If after the administration is duly commenced, as the sensibility becomes dulled the strength of vapour be not somewhat increased but a very dilute vapour continues to be given this condition often occurs. There is also the usual preliminary of sickness namely free secretion of watery saliva. Along with this condition there is often evi-:dence of depression in the circulation namely a slow and thready pulse. I remember a very marked case of this kind occurring in one of my first administrations in my student days. The patient was

a dark skinned, bilious, unhealthy looking woman, and at an early stage passed into this state. On the recommendation of the junior house surgeon, who was superintending the administration, and while the surgeon's back was turned, I took the apparently somewhat brutal method of stimulation of giving the patient a smart slap on the side of the face. Almost instantly, breathing, colour, and circulation improved and the rest of the administration presented no-thing noteworthy. Mr Wallace afterwards taught me the value of "lip friction" in such cases, which consists of briskly rubbing the lips and cheeks of the patient with a dry rough towel. The value of this procedure as a respiratory and circulatory stimulant and as a means of inhibiting sickness, can hardly be over estimated. Probably as stimulation of the nerve endings of the trigeminal nerve inhibits sneezing probably also to the same degree it inhibits vomiting. In this connection it is an interesting fact that as a rule in the very operations in which chloroform is administered in the irregular and intermittent manner which conduces to sickness, namely operations involving mouth and tongue where the lips and cheeks are continually being rubbed and manipulated by instruments and gags &c., sick-ness is rather the exception than the rule. The

operation may be frequently stopped, but it is owing to the patient coming out and not to his being sick.

The pupil in the second stage varies considerably with the amount of struggling and its concomitant semi-asphyxia. The circulation also, naturally, depends largely on the same factors; but after quiet breathing is restored, the pulse rate slows down to the normal average and usually slightly under it.

Third Stage. The patient now passes into the third stage which is that aimed at. The muscular system is relaxed, the breathing is regular with an inspiratory stertor the presence of which depends greatly on the position of the lower jaw, as it can be stopped by pushing forwards the lower jaw and with it the tongue. Respiration, as compared with that under ether is not nearly so deep and quick and unlike ether-breathing, which can nearly always be heard, may be inaudible. Regarding the breathing, we must always remember especially in a quick breathing patient, that rythmic movement of the chest walls may occur although no air whatever is entering the lungs. It is a good plan therefore, with such a patient, to have one finger on the expiratory air current. By practice, the fingers,

holding the inhaling medium can be trained that the slightest change in rythm or amplitude of the respiration can at once be detected. The pulse of this stage is usually slower than normal, the wave is small and the tension between beats is low, being unlike the full bounding pulse of ether anaesthesia. Dr Leonard Hill found by using the sphygmometer, that the blood pressure in the third stage of chloroform anaesthesia fell to from a third to a fifth of the normal. The conjunctiva, of course, is insensitive, the pupil is small, contracted, and immobile. According to Dr Hewitt, a contracted pupil means a somewhat light anaesthesia (Anaesthetics p.336) but I must say that this is not according to my experience as I am inclined to think that in a patient with a very contracted pupil the dilatation reduced by pushing the drug, is generally that of overdose

RELATIVE SAFETY OF ANAESTHETICS.

We may put nitrous oxide out of account altogether as the comparatively few fatalities which have occurred during its use, have, almost without exception, been due to gross carelessness in the administration or to some pathological state of the patient, or to a combination of both. When we consider that

it is probably given several hundred times every day, and that often by quite unqualified persons, its safe-
:ty stands assured. No fatality has been recorded when the asphyxial element has been eliminated by combining nitrous oxide with oxygen during the ad-
:ministration. Comparing chloroform with ether firstly as a protoplasmic poison, chloroform is much more toxic than ether (Lauder Brunton, Waller &c.). secondly, physiologically, chloroform kills an animal when given in much smaller quantity and in a state of much less concentration than ether. The late Professor Rutherford used to demonstrate this fact to his class by giving two rabbits an equal quantity of air which was passed through bottles of chloroform and of ether respectively, and by demonstration that the heart's action of the animal receiving chloro-
:form invariably ceased sometime before that of the animal receiving ether. Thirdly Clinically, The report of the Lancet Clinical Commission (p.193) states that "ether when properly given from an inhal-
":er permitting graduation of the strength of the "vapour is the safest general anaesthetic in temper-
":ate climes for general surgery. That chloroform "when given by a carefully trained person is a com-
":paratively safe body but is not in any case wholly "devoid of risk." The same Report (p.173) while

discussing deaths under ether, says, "Few, if any
"sudden deaths are recorded under this anaesthetic.
"most arose from interference with respiration, and
"this interference was in the large majority of
"cases, peripheral rather than central. In the cases
"in which the central nervous system became the direct
"cause of failure of respiration, it did so apparent-
":ly rather as the result of the extreme exhaustion
"of the patient due to some intercurrent disease
"e.g. prolonged strangulation of the intestine,
"rather than to over dosage." The British Medical
Association report 1900 says (p.124). "In conditions
"of good health chloroform is very much more danger-
":ous than other anaesthetics. In grave conditions
"still remains the least safe anaesthetic but the
"disparity between it and others is less marked than
"in health. When danger occurs under chloroform
"whatever its exact nature may be, there is abundant
"evidence that, in a large majority of cases, the
"symptoms that are observed are those of primary
"circulatory failure, while the respiratory compli-
":cations of anaesthesia are as a whole of equal
"frequency under the ether and the chloroform groups
"respectively, yet, those that occur under ether
"are mostly of a trifling and transitory character,
"while those occurring under chloroform are more

"grave and persistent. Ether whether employed through-
":out or preceded by nitrous oxide gas is singularly
"free from danger in healthy persons."

Such are the carefully weighed opinions of the eminent and practical men of two separate commissions which had nothing to do with experiments on animals and whose evidence was purely clinical. Statistics are notoriously fallacious, but the sum total of the following which I have been able to combine is not without some weight in supporting the opinions of the Commissions.

N.B. Since the paragraph above was written, the Annual Report of the Edinburgh Royal Infirmary for 1900 has been published. This gives six admitted deaths from chloroform in 2901 operations, i.e.a ratio of 1 in 483. It will be noticed that this is a much higher death rate than any of the following and is nearly six times greater than the average. I know of two deaths in other Edinburgh hospitals occurring within the same time, both in young and fairly robust patients. This is the cause of the impetus which has been given to ether administration within the last few months.

CHLOROFORM

Source.	Total No. of Administrations.	Total deaths.
(1). Prof. Juillard	524,507	161
(2). Dr Ormsby	152,260	53
(3). German Surg. Soc.	22,656	4
(4). Korte	133,122	46
(5). St. Barth	30,871	21
(6). Benjamin Ward Richardson	35,162	11
(7). Brit. Med. Assoc.	13,393	18
Total . .	911,971	314

Death rate - 1 in 2904·3 cases.

ETHER

(1). Juillard	314,738	21
(2). Ormsby	92,815	4
(5). St. Barth	27,916	2
(6). B.M.A.	4,595	6
Total .	440,064	33

Death rate - 1 in 13,064.

Roughly speaking ether is 5 times safer than Chloroform.

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(1). Extrait de la Revue Medicale Suisse. No. 2 Feurier 1891
(2). B.M.J. 14th April 1877 p.446.
(3). Archives fur Klin. Chirugie. Vo. XLII. pp. 282 & 301.
(4). Deutsche med. Zeit. 13th Feb. 1894.
(5). Reports 1876-1896.
(6). Asclepiad Jan. 1892.
(7). Report p.46.

CHOICE OF AN ANAESTHETIC.

This is a subject about which there is even yet, a great deal of discussion, and finality cannot be said to be in sight. The reason of this is the number of standpoints from which the subject has been viewed. Dr Snow on being asked why, if he thought that ether was so much safer than chloroform, he did not always employ the safer agent, replied, that if he thought that there would be less danger of fire from the use of flint and steel would that be a reason for not using matches. Of course with our improved methods of giving ether (this was before the days of Clover) such a comparison does not hold, but still convenience must always compete with safety. For instance, the general practitioner in the wilds of the Hebrides stands on quite a different footing from his brother of the large city, and still more from the hospital surgeon. He may have to anaesthet-:ise and operate single handed, or with the aid of quite unskilled persons. A bottle of chloroform can be carried in the waistcoat pocket, but a Clover's inhaler especially with iron nitrous oxide bottles, is a bulky thing to carry on a six miles tramp. I do not propose to go into details but con-:sider the subject from a broad common sense view. Every qualified medical practitioner should have a practical knowledge of the administration of both

ether and chloroform, the methods of avoiding dangers and of resuscitation when these have occurred. Ether can quite well be used in many cases in private practice, as after a patient is fully under the administration can be entrusted to an unskilled person with much greater safety than chloroform as the latitude in the former is much greater. Purely as an argumentum ad hominem in the first place we must, from the point of view of general practitioners, who after all form the bulk of the profession, remember that owing to the keenness of competition, a death from an anaesthetic occuring in a private practice, although the unfortunate doctor may not be one whit to blame, may mean absolute ruin to his practice, whereas to the surgeon in an hospital, although he may feel such a calamity even more keenly, yet such a consequence does not occur. It is a well known fact that many general practitioners of high standing, as they get on in years dread more and more the giving of anaesthetics in their practice. Although to a man who has the spirit of the profession at heart such an argument means little compared with the safety of his patient yet it cannot altogether be ignored. Better risk a little inconvenience and keep the mind free from anxiety, i.e. use ether as much as possible. Apart from the broad view indicated

in several special cases special agents are required. Thus the dilatation of the cerebral vessels during ether anaesthesia contra-indicates its use in the surgery of the brain. In operations about the face, mouth, nose, tongue etc. the inconvenience of the use of Clover's inhaler prevents its use. Owing to the inflammability of its vapour the actual cautery must not be brought into the neighbourhood of the head of the patient while ether is being used. The neglect of this obvious precaution has caused a number of deaths. In bronchitis and respiratory affections, generally owing to the irritant action of the ether vapour, its use should be avoided. I see no reason why empyema should contra-indicate its use as is often stated, as in one of the fatal cases which I have witnessed, namely, a rib resection, I believe to this day that if ether had been used death would not have taken place. Occasionally also owing to the tumultuous action of the abdomen in ether anaesthesia hindering a difficult abdominal operation, I have had to change to chloroform, but this is infrequent. Some of its advantages are, the circulation is not easily depressed, vomiting on the table is far more exceptional than with chloroform and thus another cause of depression is removed.

Another advantage is that owing to the powerful

breathing and good circulation the risk of constrain-:ed positions is nullified. It can be administered quite safely in the sitting position, a moderate deprivation of air has no special immediate danger, the available time for recuscitative measures is much longer than with chloroform. One advantage appeals to me as a former house surgeon and which I have never seen mentioned in any book. It is that as there is little or no depression there is little or no reaction and consequently the fear of reaction-:ary haemorrhage will be much less. For if during ether administration the bleeding be thoroughly stopped before the end of the operation then it will not be likely to begin again. This is a matter of considerable importance considering the tendency in modern surgery to disturb a wound as little as possible. If then after an operation in unbroken skin we can leave the dressing alone for several days so much the better therefore anything that less-:ens the tendency to reactionary haemorrhage, is a means to this end.

METHODS OF ADMINISTRATION.

A good method, ready resource, an unflagging attention, experience and some knowledge of the agents employed are required for the safe administration

of all anaesthetics. Experience is only gained by personal administration, not by lectures or cliniques or by seeing others administer. Here arises the vexed question of the administration of anaesthetics by students in hospitals. Now it is admitted that it would be somewhat safer for the patient if the surgeon during an operation was surrounded only by nurses and assistants who were in the habit of work-:ing with him year after year, instead of by students who are there for the purposes of education. In the same way it would be somewhat safer for the patient if a skilled administrator was on the staff of every surgical ward. But would this be for the general good? By no means. Antiseptic methods, knowledge of surgical technique, all medical training in short must be practical, and without such training no one however vast his book knowledge will ever make a surgeon, a physician, or be able properly to ad-:minister anaesthetics. Let the clerk of the case administer the agent to his own patient under the surveillance of the presumably more experienced house surgeon. By so doing his interest in his patient will be kept up throughout the entire pro-:gress of the case in hospital, and as well, the necessary self confidence will be obtained. Lord Lister writing of the administration of chloroform by clinical

clerks in the Royal Edinburgh Infirmary says - "If "I had to be placed under its influence I would rather "trust myself to one of these young gentlemen than "to the great majority of "qualified practitioners"" (Holmes Surgery Vol.III.p.608). To quote the words of an eminent surgeon regarding administration - "There is often with those who think that the giving ""of a whiff of chloroform" is a mere bagatelle, a "preliminary stage of confused struggling in which "the patient is held down . . . . . This stage is "attended by shrieks which strike terror into the "hushed and expectant relatives . . . . Then comes "a stage marked by the lavish pouring on of chloro-":form on the one hand, and the premature commence-":ment of the operation, on the other. Then a lull "attended by more pouring on of the drug, in a hasty, "unstable, and even vindictive manner . . . . a "stage of suspended animation, or artificial respira-":tion, confused runnings to and fro in which a "galvanic battery plays an uncertain part, and of "general disorganisation. After this period of "panic has subsided the operation may or may not be "completed by the exhausted operator."

From another standpoint it must be remembered that the majority of patients regard the anaesthetic with greater dread than the operation. To lie upon

a table and breathe a subtle vapour which in a few moments will cloud the anxious brain, and plunge the throbbing personality into an utter and uncertain darkness, is no slight ordeal. The patient is not best prepared for it by an administrator who solemnly displays a copious apparatus which he manipulates with the stolid ostentation of an executioner. Nor, on the other hand, is he comforted by the anaesthetist who calls jauntily for a folded handkerchief, and after placing it over the patient's trembling face, proceeds to chatter incontinently of his summer holiday. Such methods may do no harm with many patients who have nerves of iron, but with others, are not only heartless but are conducive to complica-:tions and danger. One rule may by some be thought trivial and childish, but the importance of which has been impressed upon me over and over again is - never to commence the administration to any nervous patient, or in fact to any patient at all, without first speaking a few kindly words to him to try and relieve his anxiety. Apart from politeness, which of course should not stop outside of the door of an operating room, it is perfectly marvellous how much the merest kindly enquiry or reassurance does to avert the dread of the coming ordeal, and so to render the first stages of anaesthesia pleasant and

easy. . I firmly believe that the secret of the success of some anaesthetists over others, lies in the observance of this simple act of kindness.

In this part of the paper I propose to discuss many of the methods commonly in vogue for the admin-:istration of the various agents. It is more especi-:ally my intention to discuss the methods which I have personally tried, and to mention any slight modifications which I have found to be of advantage for in the administration of anaesthetics as in any other branch of medicine "an ounce of practice is worth a pound of theory."

NITROUS OXIDE.

This agent is most commonly used for dental operations, such as extraction of teeth. It has a limited application in general surgery for short painful operations, such as opening an abscess or evulsion of a toenail, or breaking down adhesions. In a specially suitable case even a simple disloca-:tion might be reduced. As already mentioned in an earlier part of this paper, the available anaesthesia is short and means of prolonging it will be discussed afterwards. Before describing the apparatus we must

first consider what we wish to do. No special pre-:paration is required except that a meal should not have been taken within four hours of the administra-:tion. The patient should be seated in a free and unconstrained manner with all tight clothing loosened. Then with a facepiece which accurately fits the face (this should be absolutely air tight) and a reservoir of gas attached, we commence the inhalation by first washing out the air passages with the gas so as to avoid admixture with air as far as possible, then administer the pure gas until the patient is s sufficiently under, allow the operation to go on at the proper moment and afterwards superintend the recovery.

The most convenient form of apparatus consists of (1) Two iron bottles (it is always better to have two for nothing is more annoying than to have the supply run short during an administration) each con-:taining from 25 to 200 gallons of gas, according to the portability required. These are coupled together to a common tube; (2) a stout rubber tube between this union; and (3) a gas reservoir which is usually a thin rubber bag containing about two gallons. This is in its turn connected to the facepiece by a system of valves, the principle of which is that when the facepiece is firmly applied

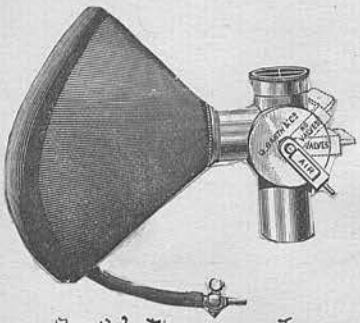


Fig. 1. Barth's Three-way Tap

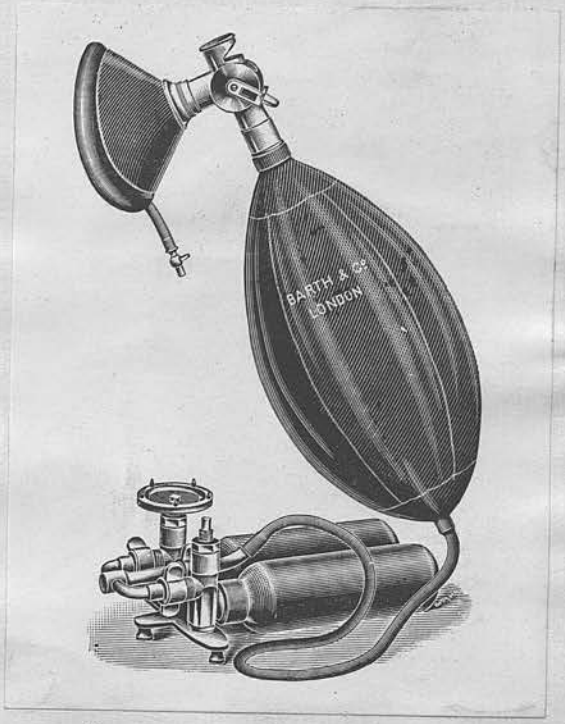


Fig. 2. Apparatus for Gas administration fitted with foot-key and Barth's tap

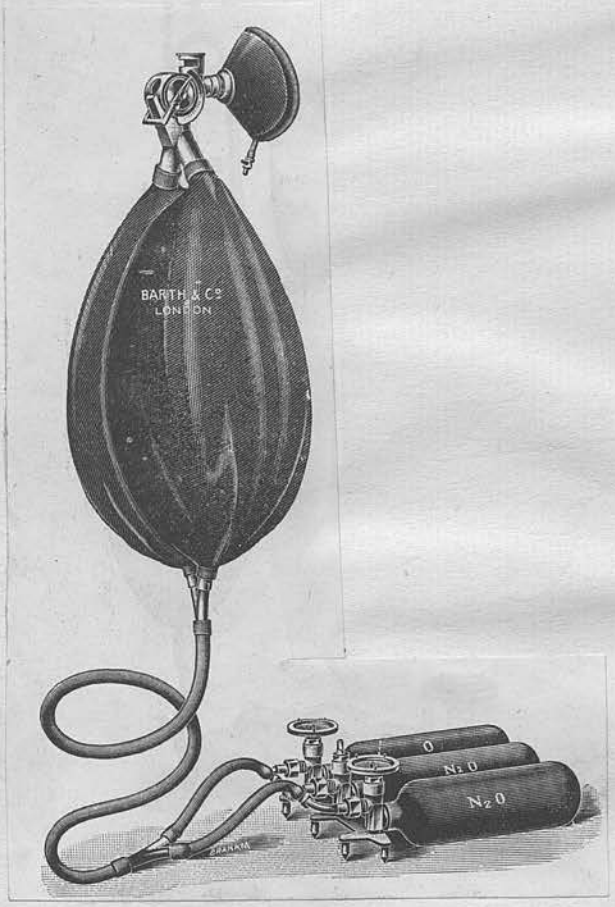


Fig. 3 Hewitt's apparatus for administration of Gas and Oxygen

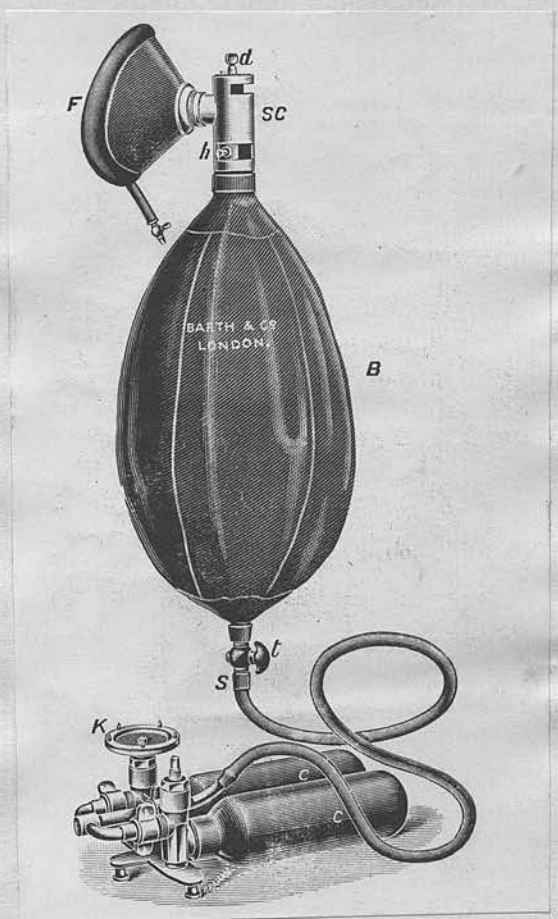


Fig. 4. Apparatus for Gas administration with foot-key and Hewitt's tap.

to the face, the air cushion with which it is pro-:vided ensuring tightness, the patient can by the simple movement of a tap be made to breathe as follows:- (a) Breathe pure air, (b) Inspire nitrous oxide and expire into the air, (c) breathe nitrous oxide back and forward into the bag. (Fig. 1) The valve which is described and illustrated here can be used for nitrous oxide alone, gas and ether, and gas followed by ether, with good results.

ADMINISTRATION.

To administer nitrous oxide, after the patient has been properly placed in an easy position, as described, first wash out all the apparatus with nitrous oxide, by turning on the gas at one of the cylinders. After this is done turn the tap to "air" which it will be remember ed shuts off the reservoir from the facepiece, then fill the gas bag until it is fully distended. (If the administrator is single-handed a foot key will be required). Apply the face-:piece firmly to the patient's face, allowing him to breathe air through the valve air way. When he is breathing quietly at the end of an inspiration turn the tap to "valves". By doing this at the end of an expiration we cut down the necessary admixture with air in the air passages to a minimum, for we

remember that admixture with air means excitement. The patient is beginning to inspire out of the bag, i.e. pure gas, and expire into the air. We may, to insure a positive pressure within the bag for the first breath or two, turn on a little more gas from the cylinder. According to Dr Hewitt if the patient is a strong man we should take more care to prevent admixture with air than in a weak and delicate per-:son, in whom a slight admixture is sometimes bene-:ficial. The patient is now rapidly washing all traces of oxygen out of his lungs so, after he has tak-:en 10 to 15 breaths of pure nitrous oxide the tap is turned to "no valves" and to and fro breathing is permitted. By this time the patient will have passed through the several stages and be"under" as will be shewn by his sterterous breathing and insen-:sitive conjunctiva. This takes on an average, 60 seconds. My own procedure here differs somewhat from that generally described. As a rule when the patient is "under" the operation is commenced but after some experiments and modifications, I have found it expedient that when, complete anaesthesia is pro-:duced the facepiece be not removed at once, but the valve tap be turned back to "air", and after the patient is allowed one or two good breaths of air it be immediately turned back to "no valves" and

to and fro breathing again permitted. Then allow an average of three breaths back and forward from from the bag and remove the facepiece and the opera-:tion can commence. By this means I believe that an available anaesthesia of 3-6 seconds longer than the average 30-5 already mentioned. Even this small addition is of use in a dental operation. Anaesthesia may be delayed by leakage of air, peculiarity of the patient and by loss of sleep on the part of the patient. This last factor was brought to my notice by the late Mr Bowman Macleod, L.D.S., who was one of the pioneers of nitrous oxide administration. Patients who have lost their sleep from pain for several nights are often very hard to get "under", and occasionally cannot be put "under" at all. Most patients come out with minds completely blank, but some have most terrible dreams, which may be so bad as to make them refuse a subsequent administra-:tion. This is often due to the too early commenc-:ing of the operation, and should not therefore occur at all. A peculiar effect of nitrous oxide administration occasionally occurs of which I have had as yet only one case. It is that of anaesthesia without loss of consciousness. The patient, a lady, was able afterwards to describe every little detail of what the operator and his assistant had done, but

had felt no pain from first to last. Of course this may have been a semi-hypnotic state but all evidences of nitrous oxide anaesthesia were present.

AFTER EFFECTS.

The patient after a period of giddiness and confusion, lasting about one or two minutes, is able to walk. Headache, sickness, or any untoward after effects are very rare. Occasionally girls become somewhat hysterical, but this is far rarer than after ether. Some nausea occasionally occurs if blood be swallowed in a dental operation.

As peculiar ideas occasionally become impressed on patients minds during gas anaesthesia, which sometimes cannot be eliminated by any evidence, it is well never to administer gas to female patients except in the presence of a third person.

DANGERS.

As already mentioned nitrous oxide is very safe, and accidents have almost without exception been due to some other concomitant than overdose. Of course if the administration be too prolonged asphyxia sets in, but the patient's condition is obviously alarming, consisting of deep cyanosis, widely dilated pupils, and anoxaemic convulsions.

This gives plenty of warning and of course the facepiece would be removed long before danger sets in. Apart from this, and especially in obese patients, or those with adenoids, or other abnormal obstruction of the air passages, these untoward symptoms may set in early. In such cases it is far better to prolong anaesthesia by one of the methods to be described, than to make any attempt to push the gas.

NITROUS OXIDE AND OXYGEN.

This is a method of obtaining anaesthesia with nitrous oxide which has been introduced by those who believe that the anoxaemia which always occurs with the method described, is not only unnecessary, but occasionally dangerous. The administration may be by means of fixed proportions mixed in a gasometer, or better by Dr Hewitt's special apparatus by which the proportions may be varied. Speaking generally, the effects as compared with those of the pure gas are:-

(1). With 5-10 % of Oxygen the production of anaesthesia is delayed so that instead of 60 seconds 100-110 seconds may elapse, before unconsciousness occurs.

(2). The patient appears asleep as no cyanosis is produced.

(3). The loud stertor, and the venous engorgement are much less than with pure gas.

(4). The available anaesthesia is somewhat longer, being about 45 seconds compared with 30·5 of the pure gas.

Physiologically speaking this method is much better than the administration of the pure gas as of course asphyxia is not a thing to aim at. But although I have had little practical experience of this method, on perusing the literature of the subject, there is to my mind a good deal of uncertainty and too large a proportion of failures, to make it compete with the methods of prolonging the effects of the gas to be described. However, Dr Hewitt has given gas by this method during somewhat prolonged operations, such as Syme's amputation, excision of the mamma &c., but he admits (op.cit.p.263) that he has had carefully to choose his cases.

OTHER METHODS.

(a). Paul Bert's method of increasing the external pressure by means of operating an air-tight chamber with the atmospheric pressure inside raised by pumps. The practical inconvenience and

expense of such a method places it out of the field of practice altogether. The anaesthesia produced by nitrous oxide in such a chamber however, is the safest and most satisfactory known.

(c). Another method of prolonging anaesthesia is by continuous administration of the gas through the nose, after the patient is under. This has the disadvantage of requiring another pair of hands.

ETHER.

The most common of the various methods of ether administration will be discussed.

I. (a). The open method
(b). The semi-open method.

II. The close method.

III. As a sequence to Nitrous oxide or chloroform.

(a). The open method was the only one which was in use before the invention of Clover's inhaler, and presents so many inconveniences that it was no wonder that, at first, chloroform swept ether aside as a routine agent. The concentration of vapour required to keep an adult patient in a state of anaesthesia is so great, that in order to get it by

pouring ether on a towel, or on lint, an enormous quantity of the agent must be used, and indeed in some of the old records it was no unusual thing to see it mentioned that so many pounds of ether were used. Another drawback was that the cold produced by the evaporation of such a quantity of ether, reduced the temperature of the inspired air to such an extent that when we remember also the somewhat irritating effects of the vapour itself, it is no wonder that ether administration got a bad name, for producing bronchitis and pneumonia. The excitation stage, of course, was unduly prolonged and the patient came out too easily. The smell of ether, as can easily be understood, clung round both patient and bystand-:ers for days. Taking all these facts into considera-:tion the administration of ether by the open method has dropped completely into abeyance. Occasionally while chloroform is being administered to a very weak or moribund patient, it is of great advan-:tage to pour ether instead of chloroform on to the lint of the mask, but very little is usually re-:quired. In such a case the improvement following such a change is very marked.

(b). The semi-open method aims at preventing the diffusion of the vapour around, and at concen-:trating the vapour inside an inhaler the principle

of which is generally speaking, a facepiece of celluloid, which is perforated and has an absorbent lining, or contains a sponge on which the ether can be poured. The best known examples are, Rendle's mask, and Allis' inhaler. (Fig. 9)

The effects differ very little from the open method and the coldness, irritation, coughing, &c. produced, make the method unpracticable, except as a sequence to chloroform in debilitated patients whose air supply must not be interfered with by an apparatus like Clover's inhaler. But as will after-:wards be shewn Clover's apparatus without the bag has all the advantages of the open and the semi-open method.

II. The close method.

This method was introduced by Clover, the ingenious inventor of the inhaler which bears his name. The principle is to have an instrument by which the vapour is very gradually increased in strength, and as the sensitive parts of the air pass-:ages become somewhat numbed from the central effect of the ether, the strength can be increased more rapidly until anaesthesia is produced. To do this some amount of re-breathing of air is for a time

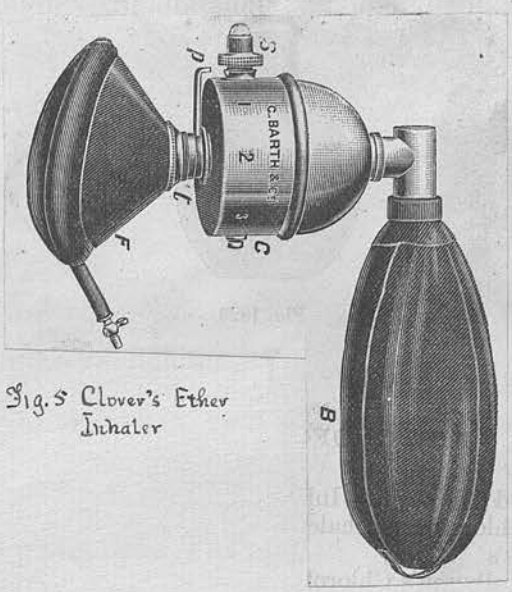


Fig. 5 Clover's Ether Inhaler

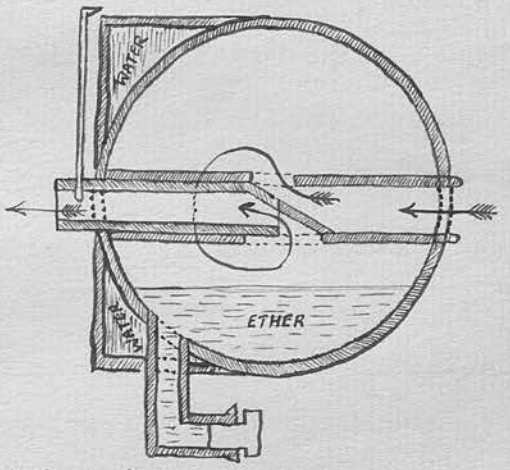
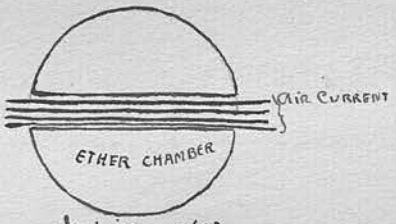
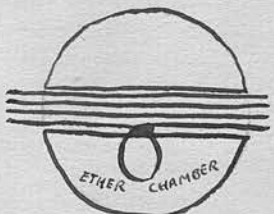


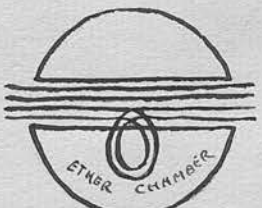
Fig. 6. Section of Clover's Portable Regulating Ether Inhaler (original pattern) Indicator at 'F'.



Indicator at '0'

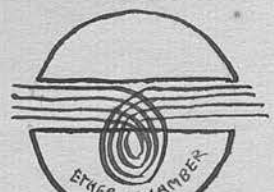


Indicator at '1'



Indicator at '2'

Indicator at '3'



Indicator at 'F' or 'full'

FIG. 7. DIAGRAM OF CLOVER'S ETHER INHALER

allowed, which being safe with this anaesthetic, greatly helps to prevent the initial irritation, coughing, holding of the breath, &c. which occur in the open and in the semi-open methods. The principle of the apparatus is, a hollow metal sphere which revolves round a stationary central tube which is connected with the facepiece on the one side, and a rubber bag, capable of holding about a gallon, on the other. An indicator fixed to the central tube and pointing to the margin of the revolving sphere, as the sphere is revolved, points to the figures O.I. II. III. and Full.. This denotes that the air passing through the central tube is deflected into the inside of the sphere, and thence to the facepiece in the proportions of O, 1/4, 1/2, 3/4, and when at "full" all the air inspired through the facepiece passes through the sphere i.e. over the contained ether. Figs. (5) (6) (7) (10)

By this means an extremely gradual increase of strength and concentration is brought about.

ADMINISTRATION.

We may take Clover's inhaler as the type of all its modifications the principle being the same. To administer ether with this apparatus, about two ounces of ether

are poured into the ether chamber, which is then corked and the indicator set at O. The facepiece is applied to the patient's face without the bag, and he is allowed to breath air through the central tube none of which passes over the ether. The patient of course should not have had a meal recently and should have all tight clothing removed. He may be sitting in a chair or lying in any position required. Care should be taken on no account to extend the head greatly as this interferes with the free swallowing of the saliva which, owing to the action of the vapour is at first poured out in large quantity. When quiet breathing is established the bag may be placed in position and gradually filled with the expired air by means of slightly lifting the facepiece off the face during inspiration and pressing it on during expiration. The bag then contains an atmosphere which is somewhat poorer in oxygen and richer in carbon dioxide than normal air. When the bag is pretty full the facepiece is applied firmly and breathing in and out of the bag occurs. At the same time the ether chamber is <u>slowly</u> revolved until the indicator points to I., shewing that one quarter of the air inspired out of the bag is passing through the ether chamber. The secret of successful admin-istration allslies in the slowness with which this

is done, and it is here that the novice fails, for if the revolution is made too fast, too strong a vapour is inhaled, and the patient coughs and splutters and pushes the inhaler away. Shortly after the in-:dicator points to I. there is usually a distinct change in the breathing, the inspirations becoming quicker and deeper. This is a sign that anaesthesia is proceeding satisfactorily and the indicator may be brought round much more quickly to II. and if no coughing or laryngeal spasm takes place, it may be brought to III. and "Full". A few breaths of fresh air may now be admitted after which the apparatus can be re-applied with occasional refilling of the bag with air, making the patient himself do this. After a few seconds the patient will ne "under" and ready for operation. After ten minutes or a quarter of an hour the bag may be removed altogether or a linen bag substituted, and the patient will be kept under as long as may be necessary, the indicator remaining at "full" or between it and III. Of course the chamber must be recharged with ether occasionally when it is observed to be empty. Of course If the rubber bag continues to be employed and so re-breathing continues to take place the indicator may be put back to II. or even I. and much less ether will be used but, at least if the operation is to take longer

than ten minutes it is far better to remove the bag altogether or use a linen one. This not only lessens the cyanosis but prevents a great deal of nausea, severe headache, and after sickness, which too prolonged re-breathing gives rise to, in many cases. An advantage of the linen bag is, that if from any reason, it is expedient to give a little chloroform during ether administration, a few drops may be allowed to fall on the outside of the linen bag which then becomes a sort of mask. This should however, be very sparingly done, and never as a routine.

During administration in the supine position, the patient's head should be slightly turned to one side, and the throat swabbed out as saliva and mucus tend to accumulate in the back of the throat.

The essentials to remember are:-

I. The indicator must travel to I. and even past it, EXTREMELY SLOWLY.

II. After the patient is "under" which is known by the stertor and the insensitive conjunctiva, use the air-tight rubber bag only if he cannot be kept "under" without, which rarely happens.

III. Do not forget to replenish the ether in the chamber.

Ether administered in this manner is a very good routine anaesthetic, and causes extremely little excitement. I have administered it in all kinds of operations, from the extraction of a single tooth to an ovariotomy or radical cure of hernia, with quite good results. I had a patient two and a half hours under ether, while an extremely complicated gastro-enterostomy was performed, using only four and a half ounces of ether, and the absence of shock was wonderful, there being much less than I have seen during many a much less severe operation under chloroform. There has been described a peculiar rash during ether administration of which I have seen only two cases, which is in the form of a spreading puffy erythema which has some of the characters of urticaria. This, as far as I have seen, began on the forehead and spread rapidly down over face and neck beyond which it did not go. It is only of a transient nature and had disappeared within an hour after the operation.

There is in conclusion, one simple point, neglect of which often causes a great deal of trouble and even failure. It is of extreme importance that the ether chamber should revolve on the centre tube with great smoothness, for if it does not do so,

jerkiness and irregularities in the strength of the vapour will result and its gradual increase which is so essential at first, will be interfered with. At the end of each day's use therefore, the inner tube should always be removed, dried, and smeared with vaseline. If this is done there need never be any sticking, requiring force to move the chamber.

Several modifications of Clover's inhaler have been devised which improve it. In Rumboll's modi-:fication the chamber is of glass, and is graduated to hold up to 2½ ounces of ether. Another advantage is that the indicator moves instead of the chamber. The bag is too small for using with gas however. Fig. (10).

Dr Hewitt has a modification which is an extreme-:ly good one. The main advantage is that the central tube is double the size of Clover's and accordingly no effort is required to breathe through this in-:haler, which is a distinct advantage.

Another form of ether inhaler commonly used is Ormsby's. This may be described as standing midway between the close and the open methods. It con-:sists of a facepiece attached to a small wire cage which is surrounded by a rubber bag which is smaller

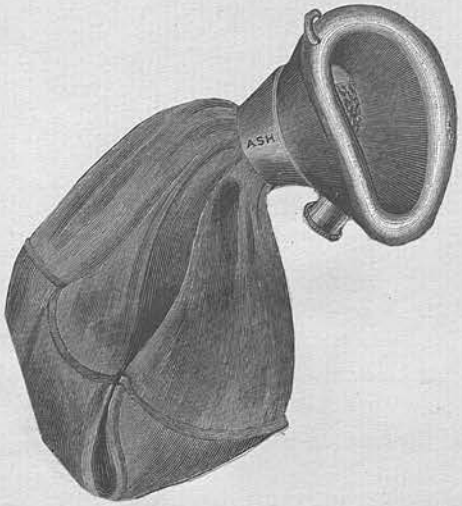


Fig 8 Ormsby's Ether Inhaler

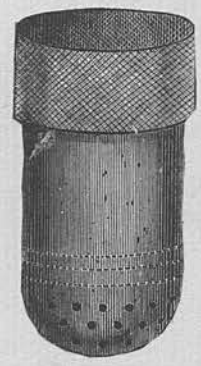


Fig. 9. Rendle's Ether mask.

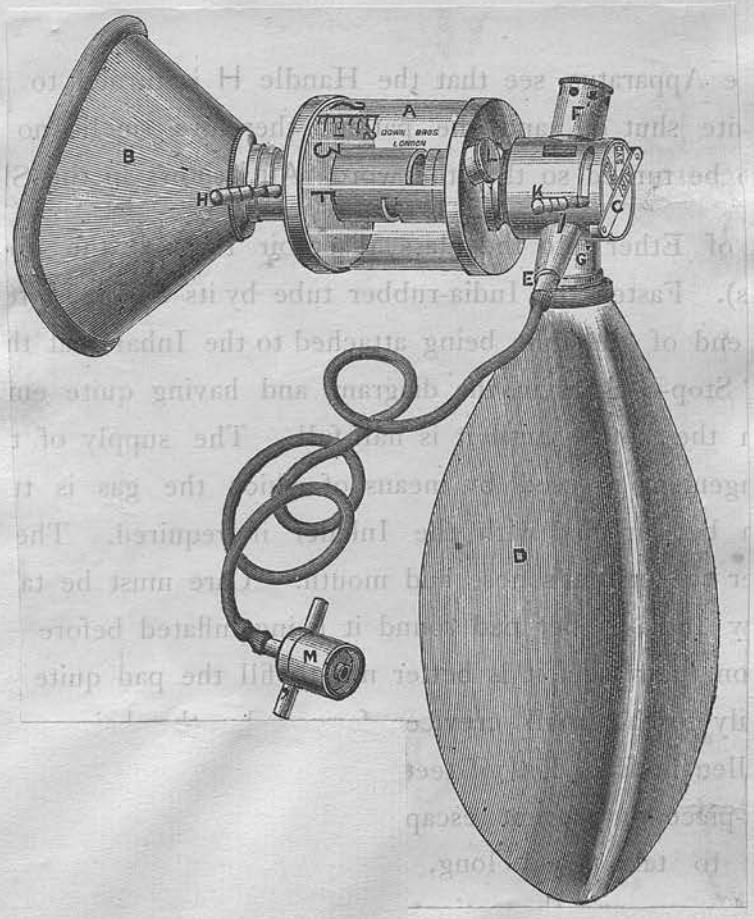


Fig. 10 Rumboll's modification of Clover's Ether Inhaler.

H. Indicator
M. N_2O terminal

than Clover's. In this cage a sponge is placed, upon which the ether is poured, and over which the patient breathes back and forward into the bag. Obviously this apparatus is not so good as Clover's for inducing anaesthesia, as the strength of the vapour cannot be regulated so well. It is good however, for maintaining anaesthesia, but presents to my mind no advantages over Clover's inhaler with the linen bag, or without the bag at all.

III. The third method will be described under "sequences".

CHLOROFORM.

There is as much difference of opinion about how chloroform should be administered as there is about how deaths occur under its influence. To begin with I will indicate the leading views on the subject.

I. The Edinburgh School of Surgery hold the views of Syme which have been mentioned. To use plenty of chloroform, watch the breathing, pull out the tongue if the breathing becomes embarrassed, is the religion of this School in a condensed form. In practice however this is carried out in a great many different ways. Take the Royal Infirmary for

instance. In one ward you see a thick towel taken folded into six, an edge including the whole six thicknesses turned up and secured by a safety pin. This is the inhaler, and is used as follows. A quantity of chloroform varying between a drachm and half an ounce is poured on the surface of this towel to which the edge has been turned, from an eight ounce bottle, the stopper of which is kept slightly out by the insertion of a safety pin. The towel is bent into the form of a cone, and is placed over the patient's mouth and nose, the turned up edge upon which no chloroform has been placed resting upon his chin. This pouring on is repeated from time to time, the patient's breath condenses on the inner side of the towel making it more and more sodden and impervious. Towards the end of an operation, the towel is a heavy mass of wet cloth sodden with chloroform, mucus, condensed moisture, and as often as not vomited matter. Many a patient have I chloro-:formed in this simple manner. The vapour strength in the inside of this damp cone varies every few seconds, and an eight ounce bottle of chloroform lasts perhaps for two or three operations. This is one interpretation of Syme's teaching. In another ward we find the corner of a towel pulled through a safety pin and on this single thickness, chloroform

is dropped from a bottle. The administration is more or less continuous and much less chloroform is used.

Other slight variations of this latter method are also used, namely, the substitution of Skinner's mask, which consists of a wire frame on which a thickness of flannel is spread, or a simple piece of lint bunched up in the middle for the corner of the towel. The users of all ~~the~~ these methods are using "plenty of chloroform", although plenty in the one case means several ounces, and in the other a drachm or two. To the Edinburgh School the use of apparatus for chloroform administration is anathema.

Now let us for a moment glance at the original methods ~~of administration~~ in this, the cradle of chloroform administration. Sir J.Y.Simpson, when he published his epoch making work, recommended the administration to be performed "powerfully and speedily", and hence recommended the folded towel, the concentrated vapour of which he alleged prevented undue excitement in the first stages (Simpson Anaesthetics p.177). Simpson later modified this view and recommended that a single layer of the towel should be used. Joseph Lister writing in 1861, warmly championed Syme's teaching, and recommended

the folded towel, pointing out that Syme had never had a fatality in 5,000 cases. (Holmes' System of Surgery Vol.III.p.598). Lister added another para-:graph to the same article, in 1870, in which he still held to his opinions but mentioned the fact that ether was making headway owing to the number of accidents with chloroform. In a third addition to his article, written in 1882 there is consider-:able change in his opinions. Ether administration is much more fully discussed and as for chloroform we find the following significant words. "If for "the fitful mode of administration by the folded "towel with atmospheres perpetually changing between "the needlessly strong and the uselessly weak, we can "substitute a method which shall give a uniform, and "at the same time a mild anaesthetic air, we may "anticipate beneficial results. The avoidance of the "needlessly strong atmospheres can hardly fail to "diminish the chance of mishap by inadvertance, and "this in two ways, firstly, by making respiratory "embarrassment less likely to occur, and secondly, "by rendering it far less dangerous to continue the "administration of the anaesthetic when the patient "is fully under its influence." Lister goes on in this article to recommend the use of the corner of the towel pulled through a safety pin, or Skinner's

mask, with a continuous administration from a drop bottle. He points out that by this method sickness on the table is much less common, than with the towel and that dangerous conditions are much less likely to occur. So the wasteful and dangerous towel is abandoned by its erstwhile greatest champion.

II. DOSIMETRIC SCHOOL.

There is a second great school of anaesthet-:ists, and one which consists mostly of Englishmen, who maintain that all deaths from chloroform are due to overdosage. The creed of this School is as follows:- Nobody administers poisons in large and unknown quantities, chloroform is a poison, Why should it be an exception to the rule? Some of these authorities use measured quantities poured on various masks &c. Obviously no one can tell how much of the drug is passing into the circulation. Others use an apparatus which is either Junker's inhaler, or some modification of it. They aim, following Snow's teaching, to keep down the percentages, and give the smallest quantities and lowest percentages con-:sistent with anaesthesia. Adherents of this system have published a large quantity of literature to show its safety, freedom from the production of sickness, &c., and have even gone the length ~~to claim~~ of claiming "absolute

safety", in lay journals. (I have incorporated ~~a~~ print-
:ed slips published by some of these gentlemen).

Very ingenious modifications of Junker's inhaler have been devised, by which the vapour percentages can be determined with more or less exactitude. For woodcuts of several of these see Figs. (11.) (12.) (14).

With regard to personal experience which al-
:ways brings facts home to one's mind in a manner in which no amount of reading will do, I have tried the methods of both schools, and several of their modifications, and comparing conclusions drawn from facts observed by myself during a considerable ex-
:perience with chloroform, with the conclusions of the reports of the B.M.A. and the Lancet Clinical Commissions, I would urge, (1), that the use of the towel folded into six thicknesses, and upon which large quantities of chloroform are poured, should be abandoned in favour of the use of the thin absorbent medium, and more or less continuous administration, recommended by Lord Lister. From a careful comparison between the two methods, I am convinced that there is far less sickness, struggling, and troubles of all sorts, by continuous administration of small quantities by Skinner's mask or some such thin medium, than by the indiscriminate pouring on of

much larger quantities on a towel, at irregular intervals. We have seen on the other hand, that intermittent administration of small quantities, not only causes delay in the production of anaesthesia but is apt to determine, especially in certain in-:dividuals, that pallor, shallow breathing, and unsatisfactory condition already described, which predisposes to sudden death, by reflex shocks or circulatory failure. As usual the middle course is safest. Let the administration be gradually com-:menced, upon a single layer of absorbent material however supported clear of the face. Let the adminis-:tration be continuous and accompanied with a free air supply. Let the effects of all concimitants, especially struggling and sickness, be carefully guarded against and let the attention never wander from the condition of the patient, whose respiration, circulation, and general appearance should be watched "not with a slavish fear, but rather with the watch-":fulness of the captain who keeps within the purview "of his attention, both the man at the wheel, and "the engineer down below."

I would again most earnestly urge that all lecturing, demonstrating, talking of any sort, do not take place within the patient's hearing during the early stages of anaesthesia. Too often also do

we see the patient being pulled about, his bandages taken off, his skin scrubbed, the position of the table altered, &c., when he is hardly out of the excitement stage. Now while admitting that in the case of ~~a~~ the pale shallow breather already mentioned, rough manipulations may improve his condition, yet as a rule the only effect is to prolong the excitement period, which it should be the aim of every administrator to cut short as much as possible. One can to a certain extent sympathise with a busy surgeon at his fifth operation running, for only one who has experienced it can realise the exhaustion produced by several prolonged operations in a hot theatre. But still I think that the few moments delay in touching the patient is in most cases time well spent, for prolongation of the excitement stage frequently tends to start the patient in a bad "style" of breathing, which is too often a preliminary of the "alarms and excursions", the result of which is thus tersely summed up in the case report, "Patient took chloroform badly".

Before leaving the subject of administration I wish to say a few words about dosimetric administration with Junker's inhaler or its modifications. Theoretically their position is excellent, and in the

hands of an expert gives very good results, but any apparatus in the hands of a man who has only occasion-:al administrations to perform is very dangerous, unless his experience has been ~~very~~ large indeed. What with the irksomeness of the continual pumping, and an apparatus with feathers, tubes, and valves, to keep an eye on, some part of the administrator's attention is bound to be removed from the main ques-:tion i.e., the condition of the patient. I am well aware of the claim for "absolute safety" from some of the partisans of this method, but apart from the fact that the word absolute, cannot be applied to anything in medicine, there have been several deaths recorded during the use of such an inhaler. (see B.M.J. 1889 p.719, 1888 p.625, 1889 p.140, 1882 p.287).

But while deprecating its use as a routine, I would like to mention one class of cases in which I have found Junker's inhaler, extremely useful. I refer to operations about the mouth, jaws or tongue. In the early days of my appointment as house surgeon I had a succession of these troublesome cases to chloroform by towel or mask. What with the patient coming out, the surgeon and his assistants pushing the mask about, and the unpleasantness of feeling in everybody's way, I used to wonder why Junker's

inhaler was not employed and the chloroform vapour led to the patient's open mouth by a long curved tube. But such was the prejudice against apparatus, that I dared not suggest such a thing. Afterwards I had an opportunity of trying this method in an ex-:cision of the tongue, and with complete success. The patient was kept well"under"the whole time, and the trouble caused by his coming out was therefore non-existent. I have since tried this method in several other operations, such as an excision of the jaw, removal of epulis &c., with equally good results. The administrator holding the curved metal tube, Fig. (15), is out of everybody's way and can watch the patient the whole time. I was glad to see that Dr Hewitt in his book, not only recommended this plan in such cases but devised a gag with terminals for tubes, by which chloroform vapour could be led into the patient's mouth. I have not had an opportunity of trying these gags, but I would be inclined to think that the use of the simple tube described would not anchor the anaesthetist so much as any attachment to a gag would do, and that therefore he would be more able to adapt his position to the movements of the surgeon. See Fig. (15).

MIXTURES OF ANAESTHETICS. I do not propose to

SAFE ADMINISTRATION OF CHLOROFORM.

Snow says:—"If the person administering chloroform can always make certain that the inspired air never contains more than 4 to 5 per cent of vapour, the pulse may be wholly disregarded, as 4 to 5 per cent. of vapour cannot seriously affect the heart's action without first intefering with the normal regularity of respiration, which should always go on freely and in the natural way." Dr. Waller and others have shown that perfect and safe anæsthesia can always be secured by the continuous inhalation of 1 to 1·5 per cent., and not above 2 per cent., of chloroform vapour. And that, if the inhalation of even 1·5 per cent. of chloroform vapour be continued after anæsthesia is already induced, the respiration becomes embarrassed and finally arrested.

HOW TO USE THE KROHNE REGULATING INHALER.

The ball should be briskly compressed between the thumb and two fingers, at the very commencement of the inspiration (commencing fall of the feather)—so that the first half of the inspiration carries the chloroform vapour into the lungs, and the pure air of the second half of the inspiration sweeps out the face-piece. Keep the ball compressed during each inspiration and relaxed during each expiration.

Each inspiration may be taken as 25 cubic inches of air. Taking the inspirations as 20 per minute, this gives 500 cubic inches as the volume of air which is drawn through the face-piece in each minute.

		At 60°,	70°,	80° Fah., equal to:—
A full compression of the small ball delivers into the face-piece	10 c.c. of air saturated with chloroform =	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$ of a minim.
,, ,, ,, middle ,, ,, ...	30 c.c. ,, ,, =	$\frac{3}{6}$	$\frac{3}{5}$	$\frac{3}{4}$,,
,, ,, ,, large ,, ,, ...	60 c.c. ,, ,, =	$\frac{6}{6}$	$\frac{6}{5}$	$\frac{6}{4}$,,

By limiting the pressure on each ball to a part of its amplitude, the above amounts of chloroform vapour can be readily reduced to still smaller fractions for each inspiration.

DOSAGE OF CHLOROFORM.

For Inducing Anæsthesia.

Cubic inches of chloroform vapour in 100 cubic inches of air.

	For each inspiration:—		per cent. of vapour.
In strong adults give from	$\frac{1}{5}$ to $\frac{4}{5}$ of a minim	=	from 0·92 to 3·68
In average ,, ,,	$\frac{1}{5}$ to $\frac{3}{5}$,,	=	,, 0.92 to 2·76
In feeble adults and older children	$\frac{1}{10}$ to $\frac{2}{5}$,,	=	,, 0·46 to 1·84
In young children and infants	$\frac{1}{20}$ to $\frac{1}{5}$,,	=	,, 0·23 to 0·92

For Maintaining Anæsthesia on an even level.

	For each inspiration:—		per cent. of vapour.
In strong adults give from	$\frac{1}{5}$ to $\frac{2}{5}$ of a minim	=	from 0·92 to 1·84
In average ,, ,,	$\frac{1}{5}$ to $\frac{2}{5}$,,	=	,, 0·92 to 1·84
In weak adults and older children	$\frac{1}{10}$ to $\frac{1}{5}$,,	=	,, 0·46 to 0·92
In young children ,,	$\frac{1}{20}$ to $\frac{1}{10}$,,	=	,, 0·23 to 0·46

Care should be taken not to disturb the respiration, and with it the circulation, for after disturbance comes depression. When the breathing becomes exaggerated, or deeper and more noisy than natural, less vapour, or no vapour, should be injected until the breathing becomes natural.

When these conditions are fulfilled, untoward symptoms resulting from overdosing cannot occur. On the other hand, "Unless the anæsthetist knows beforehand the effect he will produce with the percentage of vapour he gives with each inspiration, he should not take upon himself the responsible duty of administering one of the most beneficial but, in an overdose, one of the most poisonous drugs known, as an unsuspected overdose may cause death."

Reprinted from THE MEDICAL TIMES AND HOSPITAL GAZETTE, *September 21st*, 1895.

THE SYSTEMATIC AND PRECISE ADMINISTRATION OF CHLOROFORM.

THOUGH the quantity of ether administered by Carter is exceedingly small compared with the large quantity usually expended by other methods, yet it is enormously large compared with the much smaller quantity of chloroform that suffices for producing the same effect, and, as many eminent observers maintain, more anæsthesia proper, owing to its greater anæsthetic property over that of ether, not requiring the retention of the pernicious carbonic acid gas in the system, which is essential in inducing ether anæsthesia. To enable the reader to estimate, at a glance, the respective anæsthetic property of these two prominent anæsthetics, Carter's table of normal chloroformization is annexed, some cases of which have already been recorded in the *British Medical Journal*, December 16th, 1893, and October 10th, 1894.

It may here be observed that Carter frequently expends less ether on an average per minute in conducting normal anæsthesia than others do chloroform.

Carter, Ether (22 cases, see table MEDICAL TIMES, August 24th, 1895), average per minute 31·5 minims = 1·32 grammes.

Carter, Ether (4 cases, see table MEDICAL TIMES, August 24th, 1895), average per minute 31·4 minims = 1·31 grammes.

Kappeler in 29 cases, chloroform drop by drop, * average per minute 26·93 minims = 2·373 grammes.

Lawrie in 4 cases, chloroform (one drachm and half drachm doses), † average per minute 16·17 minims = 1·42 grammes.

Kirk in 1 case, chloroform (two drachm doses) ‡ average per minute 37·2 minims = 3·28 grammes.

The differences in the quantity of chloroform used by three experts clearly prove the uncertainty of the method employed, by which the same administrator never does and never can succeed, in spite of every care and attention, in obtaining two like results. Whereas, in whatever part of the world the systematic method is employed, uniform results are obtained with a uniform quantity of the anæsthetic.

Carter in 35 cases (see accompanying table), chloroform average per minute 4·26 minims = 0·377 grammes.

Professor Vincent (Lyons). In 78 children of both sexes, chloroform average per minute 4·58 minims = 0·404 grammes. In 28 adult females, chloroform average per minute 4 93 minims = 0·435 grammes.

Dr. Carter's thirty-five consecutive normal chloroformizations by means of Krohne's Regulating Inhaler, showing the whole quantity of chloroform administered and the quantity used on an average per minute in the youngest upwards to the oldest patient.

Year and No.	Sex.	Age.	State of health.	Nature of the operation.	Duration of administration.	Whole quantity of chloroform used.	Average per minute.	Converted into grammes one fluid drachm of Chloroform = 5·3 grammes. The whole quantity of chlorof. used.	Average chlorof. used per minute.
1894		weeks.			minutes.	drs. mnms.		grammes.	grammes.
89	M.	6		Circumcision.	5	15	3	1·32	0·26
1893		months.							
24	F.	10	Delicate	Opening abscess at side of nose, diseased bone.	10	30	3	2·65	0·26
1894		years.							
50	F.	2½	Fair	Needling lenses.	7	20	2·8	1·76	0·25
1893									
107	M.	4		Removing part of nasal septum.	10	1 30	9	7 95	0·79
1894									
71	M.	5	Delicate	Tenotomy, for hammer toe.	15	50	3·3	4·41	0·29
78	M.	5	Very bad	Removing redundancy of tissues from nares.	10	1	6	5·3	0·53
5	M.	8	Fair	Excision of cervical glands.	50	1 10	1·4	6·18	0·61
21	M.	9	Good	Cauterizing nævus on left eyelid.	10	50	5	4·41	0·44
32	F.	10	Strumous	Removing enlarged suppurating glands of neck.	40	3	4·5	15·9	0·4
39	F.	14	Anæmic from loss of blood	Accidental lacerated wound in arm; tying vessels.	35	2	3·43	10·6	0·33
1893									
122	F.	22		Dividing cervix.	15	1	4	5·3	0 34
111	F.	23		Ligaturing and excising hæmorrhoids.	30	2	4	10·6	0·35
1894									
102	F.	24		Removing large monocular cyst.	120	6 30	3·3	33·45	0·27
1893									
118	F.	26		Curetting uterus.	30	2	4	10·6	0·35

* Kappeler, "Anæsthetica" 1880. † *Lancet*, May 19th, 1894, and June 21st, 1894.
‡ *British Medical Journal*, July 14th, 1894.

Year and No.	Sex.	Age.	State of health.	Nature of the operation.	Duration of administration.	Whole quantity of chloroform used.		Average per minute.	Converted into grammes one fluid drachm of Chloroform = 5·3 grammes. The whole quantity of chlorof. used.	Average chlorof. used per minute.
105	M.	28		Castration.	60	4		4	10·12	0·33
110	F.	30		Curetting uterus.	15	1	20	6	7·06	0·45
121	F.	30		Uterine and rectal examination.	15	1	30	6	7·95	0·51
1894										
3	F.	30		Uterine examination.	15	2		8	10·6	0·7
1895										
49	F.	30	Small and delicate	Vaginal hysterectomy and removal.	78	3	20	2·7	18·55	0·23
103	F.	31		Removing uterine polypus.	20	1	22	7	7·13	0·35
1894										
90	F.	32		Stretching sphincter of anus for fissures.	13	1		4·5	5·3	0·4
1893										
116	F.	34		Curetting uterus.	35	2		4	10·6	0·3
1895										
4	F.	35	Delicate	Replacing uterus; applying pessary.	15	1	10	4·6	6·12	0·4
1893										
115	F.	36		Curetting uterus.	25	1		2·40	5·3	0·21
120	F.	36		Ruptured perineum.	60	3	40	3·67	19·42	0·32
109	F.	38		Lipoma.	40	6	40	10	34·60	0·86
117	F.	39		Curetting uterus.	35	2	30	4·28	13·25	0·37
125	F.	40		Tooth extraction.	10		20	2	1·76	0·17
106	F.	42		Removal of upper jaw.	60	8		8	42·4	0·7
119	F.	42		Curetting uterus.	30	3		6	15·9	0·53
108	F.	45		Excision of mamma.	30	2	20	4·67	17·66	0·42
101	F.	48	Fair; but extremely nervous	Removing caries of alveoli.	23	2	30	6·52	13·25	0·57
101	F.	48		Uterine examination.	25	2		4·8	10·6	0·42
1894										
33	F.	48	Fair; but extremely nervous	Removing caries of alveoli.	23	2	30	6·52	13·25	0·57
102	F.	65		Uterine examination.	15	1	40	6·67	8·82	0·58
113	F.	65		Hysterectomy.	155	8	20	3·23	44·16	0·28
Total 967 years, average 27·6.					1161	82	37	4·26	437·85	0·377

The unique uniform results obtained by Dr. Carter, and others, with a minimum quantity of the respective anæsthetic, prove conclusively that the danger-signals, usually observed under Syme's method of administration can, by Snow's method, be avoided. In not one case was dyspnœa or apnœa produced, consequently, the usual train of symptoms —cyanosis, perspiration, slow pulse, prostration, coldness and collapse, and blanching of the face— denoting sudden and complete arrest of respiration and of the heart's action produced by the sudden influence of too concentrated vapour were made an impossibility, whilst, in the words of Dr. John Snow, the "respiration is allowed to go on in the natural way."

"Physiologists speak of dyspnœa as an increase in the total energy of impulses generated in the respiratory centre, whereby breathing is rendered quicker, as well as deeper than normal. In the great majority of cases over-action of the respiration depends on an insufficiency of oxygen in the blood. Excess of carbon-dioxide does not produce the same effect. Animals can breathe an atmosphere rich in carbonic acid gas with very slight modification of the respiratory rhythm, provided there is present a sufficiency of oxygen, while diminution of oxygen, even though there be no excess of carbon dioxide, produces laboured respiration, culminating in convulsions and asphyxia." *

There are reasons for suspecting that dyspnœa under anæsthetics is frequently mistaken for natural breathing, instead of "*the most important sign of rapidly approaching danger from an overdose*"; for at coroners' inquests it is frequently stated that, the deceased took the anæsthetic well, breathing quite regularly, when "suddenly" and "without any warning," breathing ceased and the pulse could not be felt.

It would greatly help the solving of the problem "how to administer chloroform, ether, and similar anæsthetics free from risk," if those who employ Snow's (slow and cautiously progressive) method were to publish their results, say 10 or 20 consecutive cases, for comparing them with each other. As yet, the consumption of chloroform in a number of cases on an average per minute stands thus:—

Carter in his first series of 20 administrations, averages per minute 4·39 minims.

Carter in his second series of 8 administrations, averages per minute 3·8 minims.

Professor Vincent (Lyons), 78 administrations in children, averages per minute, 4·53 minims.

Professor Vincent (Lyons), 22 administrations in adult females, averages per minute 4·93 minims.

* Dyspnœa. *Clinical Journal*, May 22nd, 1895.

Reprinted from the "British & Colonial Druggist," August 19th, 1898.

CHLOROFORM AT THE EDINBURGH MEETING OF THE BRITISH MEDICAL ASSOCIATION, 1898.

A correspondent writes : Professor Annandale expressed it as his opinion (1) "that chloroform held the field as the best general anæsthetic in connection with surgical procedures; and although he had met with a few fatal results from its administration, he had most thorough confidence in its safety if carefully used and its effects diligently watched. Perhaps the best test of his confidence was the fact that having a few years ago suffered from a poisoned finger received when operating, he required to take an anæsthetic on several occasions in order to have deep incisions made for the relief of extensive suppuration. The anæsthetic he took was chloroform, and it was administered according to the 'open' method by one of his assistants, and not by any special anæsthetist. (2) It was his opinion that fatal results would occasionally take place in connection with all anæsthetics, and that these fatal cases might be divided in (*a*) avoidable, (*b*) unavoidable. The avoidable ones were those which were due to careless administration, or to neglect of means to prevent blood or other matters entering the air passages, and should not occur if proper care was exercised. To avoid these risks it was essential that one person should give sole attention to the anæsthetic and watch both respiration and pulse, more especially the respiration and its nature during the whole period of its administration. 3. The unavoidable cases were, in his opinion, the result of heart failure from fatty or other conditions, and occasionally he believed they might be caused by cerebral conditions, as he has seen a fatal case in which the symptoms resembled most an epileptic seizure. (4.) Further, Professor Annandale believed that in the majority of these unavoidable cases it was impossible, by any external examination prior to giving the anæsthetic, to discover the condition which had led to the fatal result. (5.) He was inclined to think that the avoidable accidents were more frequent than the unavoidable, and if so it taught them how important it was to avoid, by careful preparation and administration, anything likely to bring about an unfavourable result."

Some of Professor Annandale's views are quite in accord with those held by Snow, whilst others were confuted by Snow as completely 50 years ago as they are again confuted by Dr. Waller to this very day.

(1.) Snow found from independent research into the chemical and physical properties and action of chloroform what Simpson did from merely observing its effects, that chloroform, though very powerful, is a true anæsthetic, always uniform and prompt in its action, and, therefore, more trustworthy and safer than ether. Dr. Simpson recommended chloroform to be administered on a handkerchief. The objection, says Snow, to giving chloroform on a handkerchief is, that the proportion of vapour and of air cannot be properly regulated; and if there be too much vapour of chloroform in the air the patient breathes, it may cause sudden death even without previous insensibility, and whilst the blood in the lungs is of a florid colour. Though Professor Annandale had met with a few fatal results, he still advocates and teaches the "open" method, in which Snow has shown chloroform cannot be administered always with perfect safety, and to the uncertainty of which 99 per cent. of the fatal accidents from chloroform reported are due. (2.) By dividing the fatal results in avoidable and unavoidable cases, a want of thorough confidence in the patient's absolute safety under the "open" method is shown, whether the pulse, the respiration, or both be watched for symptoms arising from more or less over dosing, symptoms which should never be induced. (3) The process of inhaling chloroform, or mixtures containing chloroform from a cap, cone, piece of lint or towel, is always irregular, uncertain and unsafe, and is apt to confirm the belief in peculiarities of constitution, idiosyncrasies, and predispositions which, Snow says, have no existence in the patient. Snow never refused to administer chloroform to any patient requiring to undergo a painful operation, whether his heart was diseased or not, yet he never lost a patient in his upwards of 5,000 cases in which he had administered chloroform. (4) As Professor Annandale himself admits that preliminary stethoscopic examination does nothing towards safe administration of chloroform, such examinations are evidently useless, and as Lord Lister says are more likely to induce the dreaded syncope by alarming the patient than to avert it. The only conditions necessary to ensure uniformity of effect and perfect safety to the patient are that the chloroform be pure, and the mode of inhalation be slow and regular from a suitable inhaler; when these conditions have been rigidly observed, no fatal case has ever occurred.

(5) It is quite true that the avoidable accidents are more frequently than the unavoidable, because, as already said, there is no such a thing as an unavoidable death from the effects of pure chloroform properly administered more or less accurately measured in about $\frac{1}{20}$, $\frac{1}{10}$, $\frac{1}{5}$, $\frac{2}{5}$, and not exceeding $\frac{1}{2}$ minim doses, or from about 0.23, 0.46, 0.92, 1.15, and rarely only for a few inspirations required 2.3 per cent. of vapour of chloroform in the respired air.

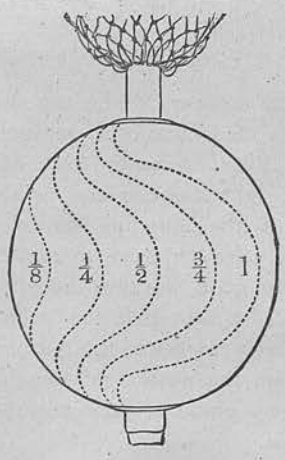
Dr. Waller has shown that the continuous inhalation of the following percentages of chloroform vapour in air are enough to secure always absolutely safe anæsthesia : 0.96, 1.18, 1.35, 1.5, and that 2 grains of chloroform = 1.5 per cent. of vapour in the air breathed have a tendency to embarrass and arrest the function of respiration, if the inhalation is continued.*

The slower and more regularly progressive the administration is, the deeper are the effects produced by a given amount of chloroform, and the safer to the patient. Deep, yet harmless anæsthesia, is always secured by the continuous administration of 1 per cent., and not exceeding 2 per cent. of vapour. But if the air the patient breathes contains from 4 to 10 per cent. and more of chloroform vapour, the risk is one of sudden death by unsuspected paralysis of the heart, from which recovery is impossible. Therefore, first learn the percentage of vapour you give with each inspiration, a knowledge which alone can give thorough confidence in your patient's absolute safety. The advocates and teachers of the "open" method appear not to bear in mind the fact that one minim of chloroform in vapour, inhaled with one inspiration, is 4.6 per cent. in the air breathed, a percentage which may cause sudden death; 2 minims equals 9.2 ; 3 minims equals 13.8 ; and 4 minims equals 18.4 per cent. are percentages Snow found certain to cause sudden death. Snow has shown from experiments on animals, and from the physiological effects and physical properties of chloroform, that accidents from this agent would arise by its suddenly paralysing the heart, if it were not sufficiently diluted with air ; and a careful review of all the recorded cases of fatal accident shows that nearly every one of them has happened in this way, and not, as Professor Annandale is inclined to think, from any neglect in watching the symptoms induced, or mistaking their import. It is to the mode of administration he advocates that deaths from accidental over-dosing with chloroform cannot always be prevented, even if its effects are diligently watched.

*Remarks on "The Dosage of Chloroform," by Augustus D. Waller, M.D., F.R.S., Lecturer on Physiology, St. Mary's Hospital Medical School (*British Medical Journal*, April 23rd, 1898).

Fig. 11. Hewitt's modification of Junker's Inhaler

The bellows or elastic ball, by which air is pumped through the Chloroform bottle, is shown here, together with the degrees of compression by which the amount of Chloroform vapour is regulated and projected into the air-way.



Chloroform Vapour in the air inhaled, about

½ %

1 %

2 %

3 %

4 %

Fig. 12

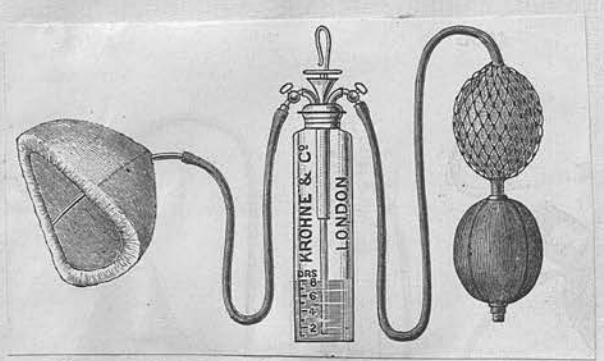


Fig. 13. Junker's Inhaler (original pattern)

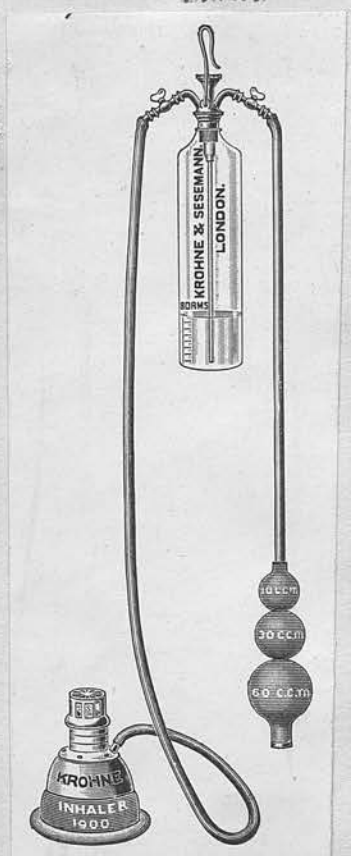


Fig. 14. Krohne's modification of Junker's Inhaler.

Fig. 15. Use of Junker's Inhaler. in operations about the mouth or throat, vapour being led into the mouth by means of a curved metal tube.

to enter into the subject of mixtures at all. The alcohol, ether and chloroform mixture, which is best known as A.C.E., stands midway between ether and chloroform in danger and utility. When it can be given however either of the other two can also be given and its use is dying out.

SEQUENCES.

The practice of giving one anaesthetic in sequence to another, has been largely developed within the last few years, and has helped much to the safety of the patient, and to the comfort of both patient and administrator.

The vapour of ether, even when given in the slow and gradual method described, cannot be borne by some few patients, owing to the choking feeling produced. Accordingly to prevent even this slight limitation to the use of ether, nitrous oxide may be given as a preliminary, and then ether is admin-:istered while the patient is under its influence. Before the patient passes out of the influence of gas he is well under that of ether, the unpleasant smell of which he has never perceived at all. This is done in two ways, firstly, some administrators give gas in the ordinary manner and while the patient is under its influence substitute Clover's or Ormbsy's

inhaler fully charged with ether and go on. There is frequently however, by this method an interregnum in which the patient comes out. The majority then administer gas through a Clover's inhaler, the only modification of which is the substitution of a large two gallon bag for the somewhat smaller one described.

I will describe the method which I have largely used in the Edinburgh Dental Hospital, but before doing so I wish to differentiate between "gas and ether" and"gas followed by ether". The first method has been placed before the profession by Mr Guy, F.R.C.S.E. in an admirable article in the Edinburgh Hospital Reports 1900. It is largely used both in the Royal Infirmary Dental Department, and in the Dental Hospital. It consists essentially in the prolonga-:tion of the effect of gas by the administration of ether with it. "Gas followed by ether" on the other hand is essentially an ether anaesthesia preceded by gas.

The apparatus used is a Clover's inhaler, charg-:ed with two ounces of ether, with the large bag mentioned, having at its lower end a tap by which it can be filled, and if necessary detached from the bottle. This bag is connected by identically the same three way tap already described under gas

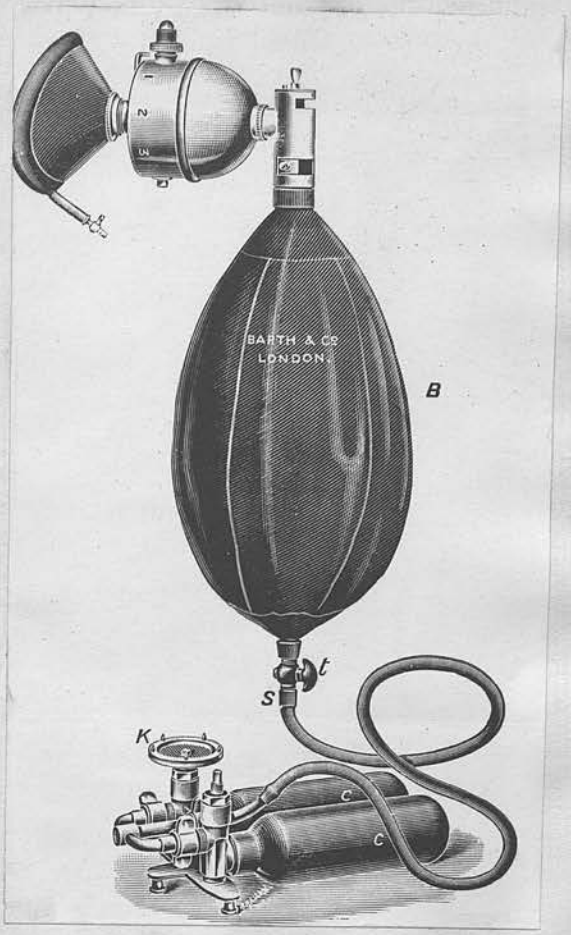


Fig. 16. Apparatus for "Gas and Ether". and "Gas followed by Ether". fitted with Hewitt's valve.

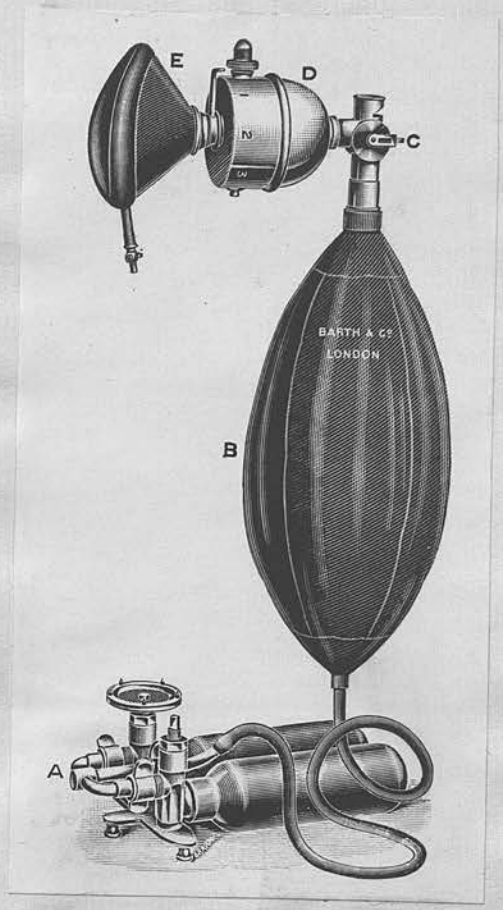


Fig. 17 Apparatus for "Gas + Ether" and "Gas followed by Ether" fitted with BARTH's valve.

Fig. 18. Anaesthetic bag containing all the requisites for the administration of ~~N_2O~~ NITROUS OXIDE, ETHER, CHLOROFORM, with gags, and box with restoratives and 2-25 gallon steel bottles containing sufficient gas for at least 15 administrations

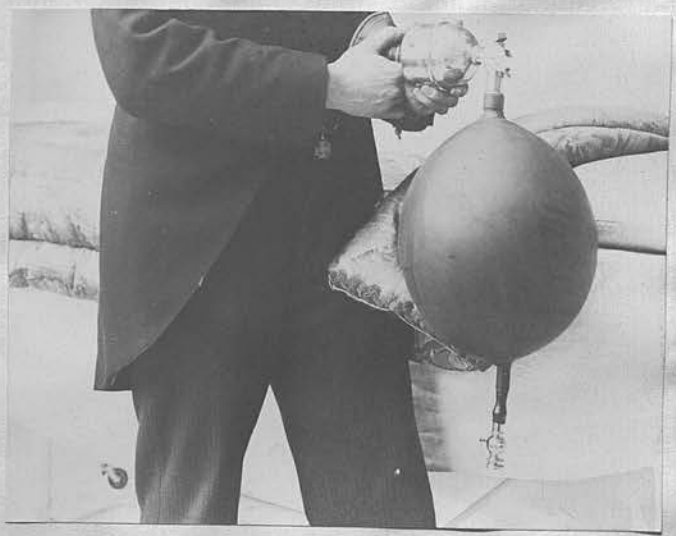


Fig. 19. Apparatus for "Gas + Ether" and "Gas followed by Ether", charged and detached from gas bottles.

administration. The tap is turned to "air" and the bag filled with gas, after being washed out with it as already described. The whole system viz:- Clover's inhaler with bag, can be detached from the gas cylinder, as in Fig.(19).

Now up to a certain point "gas and ether" is identical with "gas followed by ether", namely, the facepiece being applied, indicator set at O the tap is placed at "valves" and the air in the patient's lungs washed out exactly as with gas alone. After the usual six or seven breaths, the tap is turned to "no valves" and to and fro breathing permitted. At the same time as the patient is beginning to get under the influence of gas, the cylinder is gradually turned to I. then on to "Full". This can usually be done much more quickly than with ether alone, as the irritability of the larynx, is lessened by gas anaesthesia. After a few breaths with the indicator in this position the apparatus can be removed and the available anaesthesia instead of being thirty seconds is two and a half to three minutes, during which several teeth may be removed. Now if a still longer anaesthesia be desired, the apparatus is kept on the face, and keeping the indicator still at "Full" the tap may be turned back to "air " and

so alternating between "air" and "no valves", the patient's system can be so"charged up" with ether that an available anaesthesia of four to twelve minutes may be obtained. This however is essentially an"ether anaesthesia" so for convenience we may call it "gas followed by ether". I took the times of 32 patients with whom I used this method in the Dental Hospital with the following averages:-

(a). Time from application of inhaler to re-breathing - 10 seconds

(b). Time from commencement of re-breathing to indicator at "Full" - 50 seconds

(c). Breathing of mixed air and gas from bag with occasional breath of fresh air all however through ether chamber with indicat-:or at "Full" - 122 seconds.

(d). Average time of available anaesthesia, i.e. to the time at which struggling commenced - 6·5 minutes.

The average age of these patients was 24 years.

Twenty-three of them were young women and the rest young men. In 17 of the cases the patient was reclining on a couch, the rest were seated

on a dental chair. None of then were prepared for operation except that they had not had a meal within four or five hours previous to the administration. In a few cases the ether had to be replenished, but in most, less than two ounces were used.

Of course if the administration of gas was just a preliminary to ether, as already mentioned, ether administration goes on in the usual manner.

Other sequences such as"chloroform and ether" are used, in which chloroform takes the place of gas to prevent the disagreeable preliminaries. It is useful in cases in which the patient is too ill, or has heart disease, or in any condition in which the asphyxial element of gas is contra indicated. As a routine it is not so much used and we cannot wonder at this when we remember that many fatalities occurring with chloroform, occur early in the ad-:ministration, and as the whole raison d'étre for ether administration is to avoid danger as much as possible, the use of chloroform as a preliminary would somewhat militate against this. "Ether-chloro-:form" sequence may take place in the few cases mentioned, when owing to the movement of the abdominal walls from bellows like respiration under ether,

operative procedures come to a stand still; such cases are uncommon. Chloroform of course, must never be given with, or immediately after, gas, as to add the action of chloroform to the asphyxial action of gas would be extremely dangerous.

DENTAL OPERATIONS.

I have devoted a special paragraph to the administration of anaesthetics for dental purposes, for two reasons. Firstly, the relative deathrate under chloroform of this class of operation is enormous, and secondly, during a dental operation is perhaps the commonest occasion on which a general practitioner has to give an anaesthetic. Mr Guy, L.D.S. in the article already mentioned, introducing his subject says,""I would rather give chloroform for "any operation than tooth extraction" is a remark I "have heard so frequently from ~~the~~ medical practi-":tioners that I am beginning to regard it as common-"place."

Dt Hewitt in his address to the British Dental Association in 1895, tabulated twenty-eight fatal-:ities as occurring in Great Britain from 1880-1890, during such operations, against eight for methylene, ether, and nitrous oxide together. ((Brit. Dental

Assoc.Journal 1895 p.364). In the same article Dr Hewitt pointed out that the ratio of the death rate compared with the population is much higher where chloroform is used as a routine, than where gas and ether are used. Turning to the Lancet Commission's Report, out of the 682 deaths under chloroform which were tabulated, 57 occurred during trivial dental operations. This works out something like one death in dental operations to every 11 in general surgery. Now what is the cause of this lamentable state of affairs? Firstly, we must recognise the fact that the extraction of a number of teeth, in-:volving as it does a region richly supplied with nerves, and in a patient who is frequently worn out with loss of sleep,and pain, is an operation in which a considerable degree of shock may occur. Secondly, The operation involves the air passages, and there is a risk of impaction of foreign bodies, such as blood clots, bits of teeth, &c. Thirdly, there is a tendency on the part of the dentist to prefer the semi-sitting posture, which of course is the most convenient for him, and we have seen that this is dangerous. A "whiff" of chloroform is administered by one who perhaps is a little out of practice, this is not enough to obviate pain but only enough to weaken the sense of resolution with

which the patient has steeled himself to the opera-
:tion. Small wonder then that reflex syncope occurs,
especially as the operator frequently by pushing
back the lower jaw effectually blocks the trachea and
adds an asphyxial element, a state of affairs which
is assisted by the presence of sponges, blood, and a
large gag.

Now by using ether, gas and ether, or "gas
followed by ether", we can have a very much safer
anaesthesia than by chloroform. The patient re-
:quires no preparation except a fairly empty stomach,
cardiac syncope is almost impossible owing to the
stimulating qualities of the ether vapour, (non-
:depressing if we think with Schmiedeberg). These
advantages coupled with the quick recovery, and the
far slighter after sickness, render it unnecessary
and even criminal to expose any patient to even the
slightest risk of cardiac syncope, or of drawing
foreign bodies into his trachea which the required
supine position necessarily entails, and which are
never absent during chloroform administration.
Since my appointment as anaesthetist to the Edinburgh
Dental Hospital, two and a half years ago, I have
never seen any patient in a state which might be

described as remotely approaching a dangerous one, while under the influence of either gas or ether, whether singly or in sequence. If our anxiety can be lessened in this manner what boots it that the dentist complains of the increased vascularity tending to hide things and hinder his work? The true operator after all has eyes on the points of his fingers.

Now before leaving this subject I wish just to refer to the portability of the apparatus I employ.

A bag Fig. (18) which can easily be carried at least, a short distance, I have the following articles packed:-

1 Clover's inhaler with 1 linen, 1 small, and 1 large rubber bag.

1 bottle containing ether for 4 or 5 inhalations.

1 drop bottle containing 4 ounces chloroform.

1 Skinner's mask.

2 bottles nitrous oxide each containing 25 gallons, with union key and supply tube complete to fit to large rubber bag.

1 metal measure holding 2 ounces for ether.

Various gags, spongeholders, &c.

1 case containing hypodermic syringe, solutions of adrenalin, strychnine and strophanthin, alcohol, &c. tongue forceps, bistoury, tracheotomy forceps, wedge for separating teeth, a tracheotomy tube, and catgut needle &c.

Such a bag is extremely useful and has only one draw-back, namely, the weight of the small iron bottles.

ADMINISTRATION TO CHILDREN.

Speaking generally children take chloroform well, and unless for some special reason, such as great cachexia or exhaustion, this should be the anaesthetic chosen, at least at first, and this the more especially as apparatus is apt to frighten them very much. If we avoid the pitfall of overdosage, which may take place in the manner already mentioned after sleeping or during crying there are not many other causes of anxiety. There is however one type of child with which I have seem some difficulties, and in two cases rather narrow escapes. This, I am informed, has also been the experience of others. I refer to the pale, lymphatic child with blue eyes and a fair complexion. This child is often the subject of adenoids, and this fact perhaps gives anaesthesia for adenoid removal, such a bad name with English anaesthetists. (Trans.Soc.Anaesthetists Vol II.p.105) The form of trouble to which I refer is the cessation of respiration and lividity occurring early in the anaesthesia. There is not necessarily blocking of the air passages at all, although of course this would help. The child appears to stop breathing

more or less suddenly and without warning, and though restorative measures such as pulling out of the tongue and artificial respiration usually restart the breathing, yet occasionally this does not occur for some time, and the lividity and dilated pupils mark impending circulatory failure. In one of the two cases mentioned, artificial respiration was persisted in for eight or ten minutes before any attempt at inspiration was made by the patient. Such children should accordingly never be lifted or carried about while under the influence of chloroform.

MEANS OF RESUSCITATION.

Anaesthesia should never, except in grave emergencies, be produced without a third person being present. Preferably there should be more than two present, so that if any emergency arises, restorative measures can at once be commenced. There should always be at hand, a pair of tongue forceps, a gag, and a wedge for pressing open clenched teeth. Less essential but still very important are a hypodermic syringe, with strychmine or adrenalin, hot water, and instruments for tracheotomy.

The indications in accidents are:-

(1). To keep open the respiratory passages.

(2). To raise the blood pressure in the respira-:tory centre and brain generally.

(3). To keep up oxygenation of the blood until natural respiration commences.

(4). Prevent heart failure by stimulation as well as by (1), (2), & (3).

As already shewn it is to Leonard Hill that we owe the proof that lowering the head in animals chloroformed to the point of failure of respiration, so stimulates the respiratory centre that respira-:tion recommences. This has been proved clinically over and over again. Therefore if any of the com-:plications of anaesthesia arise, which cause cessa-:tion of respiration, the first thing to be done is instantly to remove the mask or other vehicle of administra-:tion, ~~at once~~. If respiration does not recommence at once, pull out the tongue with the tongue forceps, which should always be at hand. Undoubtedly the best forceps to use are the old sharp pointed spring artery forceps, as the mouth often cannot quickly be opened far enough to admit the larger triangular tongue forceps. Pulling out the tongue not only widens the air passages but is a powerful stimulant

of respiration. If this fails, then, keeping the tongue pulled out, instantly lower the patient's head and commence arificial respiration. Dr Foulis' glossotilt is often of use but requires another hand.

Now, these procedures are essential and should be done <u>first</u>. If plenty of assistance is at hand hypodermic medication and applications of hot water cloths to the percordium may be simultaneously em-:ployed, but on no account, should any administration of drugs delay, in the slightest degree, attention to the all important points of treatment, lowering the head and commencing artificial respiration.

Strychnine is a valuable respiratory and cardiac stimulant, and if the circulation is going on however sluggishly, it is certain to do good. I do not think that the charged hypodermic syringe of ether, which we see in almost every operating theatre, does the slightest good in a real case of cardiac and respir-:atory failure. It may be of use in the same cases i.e. sluggish breathing early in the administration, in which lip friction does good, from the severe pain produced at the point of injection. I made a series of observations in collapsed and moribund patients, in the Leith Hospital, with hypodermic injections of sulphuric ether, and became quite satisfied that

although in many cases a slight improvement in the pulse took place, the effect was so transient and passed so quickly away, that no benefit resulted. Dr Hewitt after forty years' experience, remarks that he never saw the slightest benefit arise from hypo-:dermic injection of ether in difficulties during anaesthesia.

A new and comparatively untried drug, namely, Takamine's adrenalin solution, should give very good results as an agent for raising blood pressure. Strophanthin and digitalin have their uses also but these are all adjuvants simply to the main remedy, artificial respiration.

In conclusion, artificial respiration should be kept up for at least half an hour before hope is given up. Several cases are on record, in which recoveries took place at a longer interval than this.

AFTER EFFECTS.

The normal after history of the patient may be described as a period of confusion and in-:difference to surroundings, for an hour or two after the operation, accompanied by more or less nausea and shock. The temperament of the patient, the nature

of the operation, &c., of course greatly modify the after history. Children as a rule pass into a natural sleep which is beneficial and should on no account be broken in upon. Anxious relatives are great sinners in this respect, for as often as not, they refuse to believe that the patient can be "out" without some manifestation that this is the case, such as crying or speaking. Thus the sleep which seems to be a wise provision of nature to diminish the after pain, is nullified in its effect.

AFTER SICKNESS.

This is a very painful and distressing complication, which is always harmful to a greater or less extent. The severity varies from slight nausea lasting some hours, to severe and prolonged vomiting which so exhausts the patient that death may take place. With nitrous oxide, sickness is quite exceptional. With ether, the after sickness generally takes the form of being a short attack of vomiting immediately after the operation, which soon passes off. With chloroform the nausea and vomiting is usually more prolonged. My own experience is that there is extremely little sickness of any kind from first to last with ether, but I am aware that this

does not agree with that of others. With chloroform on the other hand, the following patients seem to be especially prone to sickness, apart from those in whom the operation has been on some part of the alimentary tract.

(a). Patients who have been nauseated by the calomel or other means used to clear the bowels before operation.

(b). Patients who have tuberculosis of some part of the genito-urinary tract, more especially if iodoform has been used. Some of the worst cases of prolonged chloroform sickness have been in patients in whom the kidneys or bladder have been operated on for tubercle.

With regard to (a) in referring again to the subject of preparation, some of the cases of greatest anxiety which I have witnessed, whether from collapse and difficulties during administration, or prolonged after sickness, have been in patients whose operation for some reason has been postponed for 24 hours. Whether owing to the hope deferred, or to the effects of a second long abstinence from food, I do not know, but this I have had corroborated by several house surgeons.

TREATMENT.

(1). Preventative. As already mentioned, preparation for operation should be more gradual and less drastic than is the rule at present. The giv-:ing of a light easily assimilable nourishment with-:in three hours of the operation, does a great deal, in my opinion, to prevent after sickness. Drugs are of far less importance, with one exception. A new synthetical product, chloretone, in 15 grain doses, before operation, seems to have a very good effect in preventing sickness, both on the table and after-:wards. A series of cases in which this agent was tried with good result, were published in an American Journal (Kansas Medical Record July 1901). I have not as yet had an opportunity of trying it but Dr M'Callum, Edinburgh, informed me that after a pro-:longed trial he thinks that it should be given as a routine before anaesthesia.

(2). Treatment when sickness has set in. If sickness persists for several hours, the patient, owing to want of rest and exhaustion, must ~~be~~ of necessity be harmed, and accordingly means must be taken to put a stop to it. There are a number of remedies of more or less value, which are recommended

such as, sucking of ice, koumiss, iced coffee, sipping of hot water with or without soda bicarbonate dissolved in it, and in more severe cases, application of mustard to the epigastrium, and lavage. I have seen all these remedies do good with the exception of the sucking of ice, and of the iced coffee, from the former of which I never could make out any benefit, and the latter I have never seen tried. Perhaps as good a method as any, if the vomiting perisits for more than two hours, is to give a large cup of very hot weak tea, with milk and sugar if preferred, if this is retained good and well, if not, the stomach is washed out, and this of itself may stop the sickness. It is much more pleasant to the patient than simple hot water, and equally efficacious, and may be repeated. If this is ineffectual, then sips of iced water may be tried, and this occasionally succeeds when the hot fluid fails. Failing this, then counter irritation to the epigastrium, and, if necessary, washing out of the stomach with the usual funnel and soft tube, must be resorted to. Warm water tinged with permanganate of potash solution is a good fluid to use. Of course this should not be tried until all other means fail as it disturbs the patient a good deal. Morphia $\frac{1}{8}$ gr. with Atropine sulphate 1/100 gr. hypodermically, also

tends to have a sedative action in prolonged sickness. Of course the patient's strength must be maintained by nutrient enemata while the sickness lasts.

BRONCHITIS AND PNEUMONIA.

In a small proportion of cases especially in hospital patients, the after recovery is interferred with, by ~~the onset of~~ bronchitis or pneumonia supervening. Now, until perhaps within the last year, if any senior student was asked in Edinburgh, why ether was not more generally used, in nine cases out of ten the glib reply would be made "because it "causes bronchitis". Ether has a bad name for causing respiratory troubles afterwards, and this, as usual, dies hard. But let us examine the facts. As has already been discussed, before the days of Clover's inhaler, the patient had often to inhale the ice cold and somewhat irritating vapour obtained by the open method. The open method also greatly prolonged the operation owing to the unsatisfactory anaesthesia. No wonder, taking all this into account, that bronchitis and even pneumonia supervened rather oftener than was creditable. Ether is only now losing the bad reputation obtained in those days. The Society of Anaesthetists have had several enquiries

into the frequency of such accidents, and different members have brought forward statistics which shew, that there is no doubt, that in a few cases broncho-pneumonia does supervene after ether administration but that this is rare. 1 in 2,910, 0 in 4000, 17 in 4,914 administrations were some of the ratios obtained. (out of 17 cases in the third series 4 occurred sooner than 4 days, the rest occurring between the 10th and the 25th day after the opera-:tion). However there was a good deal of difference of opinion among the observers as to what was due to the anaesthetic, and what was owing to other causes. Almost every case reported in these discussions was in an hospital patient, in whom the factors of draughty passages and large wards must be taken into account. (Trans.Soc.Anaesthetists Vol.III.p.55). We are rather apt to forget also, that such accidents after chloroform are by no means unknown. I have notes of two cases of pneumonia and five of bron-:chitis, among hospital in-patients, which came on within four days of the operation under chloroform. Whereas I have never seen the slightest bronchial catarrh follow ether even after prolonged administration. The frequency of occurrence of these respiratory after effects, can only be settled by careful note taking in a large number of cases. There are several

means which we can take to prevent, as much as poss-
:ible, the after occurrence of respiratory troubles.
By limiting the area of skin exposed as much as
possible during the operation, by removing all wet
cloths or clothes, from the patient before taking
him out of the hot theatre, by covering him up well
while traversing passages, & by minimising as much
as possible tight bandaging of the trunk. All this
tends to diminish the risk of chill which, superadded
to the lowering of temperature, which occurs in every
prolonged operation, and which seems to have more to
do with the causation of after bronchitis or pneumonia
than the anaesthetic agent employed. There are two
minor after effects of ether which I will just men-
:tion. Frequently patients, especially young women,
become hysterical immediately after ether administra-
:tion. Beyond preventing them from falling or in-
:juring themselves, there is no need of any particu-
:lar treatment. This is especially prone to occur
when the patient has been "charged up" with ether,
in the manner already mentioned. Headache occasion-
:ally is somewhat severe, and as a rule the severity
is directly proportional to the length of time dur-
:ing which the patient was rebreathing out of the
rubber bag. The less the rubber bag is used the
less chance there is of after headache, which as a

rule quickly passes off.

After effects such as jaundice, albuminuria, and even insanity have been described, but their occurrence is so rare that in a paper devoted to the practicalaspects of the subject their discussion would be out of place.

OTHER ANAESTHETICS.

Bromide of ethyl, chloride of ethyl, methylene, pental, have all been used as anaesthetics, but their use is so limited that I do not propose to consider them. Keléne, a very pure chloride of ethyl, has been lately used to a considerable extent among dentists, with varying results. I have found it a convenient substitute for nitrous oxide as a preliminary to ether administration. It is however very expensive and this is against its use as a routine. Bromide of ethyl was within the last year given a trial, in the ear and throat department in the Royal Infirmary, but was not continued owing to its unreliability. In many cases the anaesthesia was so light as to be very inconvenient, but of course with increased experience this might be improved.

In conclusion I shall give a resumé of what has been impressed upon me during the time I have made

a special study of anaesthesia.

I. The giving of anaesthetics is, in no case, a trifling matter to be lightly undertaken. Therefore the expression "a whiff of chloroform" should never be used by surgical teachers.

II. While, for general purposes, ether will never altogether displace chloroform, yet, as a routine, it should be used as much as possible. No anaesthetist should be so bigoted as to condemn any agent which he has not tried.

III. Chloroform should never be used in dental operations unless in the most exceptional circumstances, and should never be given to any patient unless such patient is in the horizontal position.

IV. Starvation and clearing out of the intestine before operation can be overdone.

V. The administrator should attend to the business in hand and to nothing else. The gift of instinctively knowing that the breathing is altering in character and of foreseeing impending difficulties should be cultivated.

VI. The anaesthetist is made, not born.

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