ANÆSTHETICS.

BY

EDWARD R. SQUIBB, M. D.,

OF BROOKLYN, N. Y.

Read before the Medical Society of the State of New York, February 8, 1871; and by authority of the Society published in advance of the volume of Transactions, in the New York Medical Journal, April, 1871.

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TIME, that tries all things, has disposed of many of the issues which arose in the early application of anæsthesia, but has entirely failed in producing that universally applicable anæsthetic—that philosopher's stone for which the alchemists of the profession still vainly search—namely, an agent which shall be potent, but potent only for good. This physical impossibility seems to be to the medical profession what perpetual motion is to mechanics, and time wears away such heresies very slowly. It would, doubtless, be better for the profession and for mankind if the anæsthetics already known were better studied in relation to their special adaptations, and were applied with a more wise discrimination.

The condition of perfect anæsthesia is one of the most grave and frightful conditions of life, and by suspending more than half of vitality it comes so near to death that it is wonderful to reflect how near that boundary-line can be approached and yet be so rarely passed. Familiarity with anæsthesia, and a mere distant view of its accidents, lead the profession to plunge their patients into it with too much recklessness. This condition, now so familiar to all, when seen but a few years ago, never failed to excite the gravest appre-

hension; and even now, when seen as the effect of other narcotic poisons, causes much anxiety and secures the most active measures for relief.

So much does it become a matter of personal or local habit or practice to use one or other anæsthetic exclusively, regardless of risks or warnings, and to defend this exclusive practice against all who doubt its wisdom, that each little circle in the profession, or each man, requires, as in the instance of this writer, some grave accident to awaken a sense of proper responsibility, and teach the wisdom of discrimination.

The roughly-expressed though perhaps practical condition essential to anæsthesia, is diminished oxidation in the sensorium; and the primary object is, to confine this within the limits of safety. It is a kind of partial suffocation or asphyxia occurring not in the organs of respiration and circulation primarily, but far back of these in the tissues where the vital act of oxidation occurs. The air-passages normally admit oxygen, and the blood takes it up and carries it, but carries with it an agent which prevents its assimilation in the tissues which preside over vitality. To diminish this assimilation seems to constitute anæsthesia. To prevent it is death by narcosis. Hence the only line of safety in practice, in the present state of knowledge, is to regard the difference between anæsthesia and death as a difference in degree or quantity only. The condition may be partial, full, profound, or fatal, but with no distinct boundary-lines between the degrees. The two intermediate degrees constitute anæsthesia proper, and the first of these is desired in medicine and surgery. In the production of this anæsthesia the more powerful, prompt, and efficient the agent, and the more impressible the individual organization upon which it acts, the greater the liability to overleap the intermediate stages or degrees, and unexpectedly extinguish life. This seems but common-sense, and physicians are familiar with the principle in the toxic influence of all acute diseases, though they often fail to apply it in this most acute of all diseased conditions wherein the issues of life and death are narrowed down, not to a few hours, but within a few minutes. Add to this the fact that this condition rests with the physi-

cian whether to produce it or not, and it is difficult to understand how its importance can be over-estimated.

The agents commonly used to produce anæsthesia, and now called anæsthetics, were formerly all classed as diffusible stimulants, because, in studying them, writers had not gone beyond their prominent primary effect. Now, however, this stimulation is regarded as the first of four degrees or stages into which their total effects may be usefully divided; and it is remarkable that the first and last of these stages are in such absolute antagonism that, studied separately and independent of a known cause, the agent producing the one would naturally suggest itself as an antidote to the other. The most important relations between these agents and the different degrees or stages of their effects, are quantity and potency or inherent strength; and these are again but relative to the susceptibility upon which they act. A fluidounce of alcohol would stimulate an adult, and four fluidounces would narcotize him, but with distinct intermediate stages. The same quantities of the same agent would destroy an infant by narcotism, without any distinct intermediate stages from either dose. One-eighth of these quantities of chloroform would produce similar results from its inherent potency, in one-eighth of the time, and the rapidity of its action would amount to suddenness, and hence to the obliteration of intermediate stages. The more potent the agent the shorter is its course, and the fewer and less distinct the intermediate steps by which the ultimate result is reached. Add to this the circumstance that this potency involves the risk of incidental or accidental complications which tend to precipitate the normal calculated results.

Narcosis is progressive, and may advance symmetrically or asymmetrically. That is, all the vital functions may be equally and uniformly depressed to obliteration; or, the narcotic influence may, in any part of its progress, be concentrated upon some one vital function or organ, and thus interrupt the progress by a short-cut to the end.

All this is intended to exhibit anæsthesia as a stage more than midway in a pathological course, the natural terminus

of which is extinction of life; and that to produce and maintain this stage of narcosis with safety is a very delicate question of the application of means to an end, the grave importance of which is too often disregarded upon insufficient grounds. The accomplishment of any given amount of work with the utmost promptitude and certainty renders an excess of power necessary, and the greater this excess of power the more difficult it is to control the power with safety to the work. This just relation between the work to be done and the power which is applied to do it, involves the whole question of choosing an anæsthetic, and equally forbids the arbitrary or habitual use or exclusion of either of the well-known and well-tried agents, while it imposes a grave responsibility, first in the selection, and then in the application, of the special agent selected.

Dr. Augustus Waller, of Geneva (see *The Practitioner* for December, 1870), proposes compression of the pneumogastric nerves in the neck as a safe way of procuring temporary anæsthesia in some cases. Should any such mechanical means as this ever be found practically successful, even in a small proportion of cases, it would be a great gain for minor surgery.

The anæsthetics that have been well tried up to the present time are three in number; and, with proper discrimination in applying each of these to its appropriate uses only, and proper skill in using each, all the legitimate purposes of anæsthesia can be well accomplished with reasonable safety. These three anæsthetics are nitrous oxide, ether, and chloroform; and they are all in extensive daily use in this country at this time.

It happened, however, that, after the application of chloroform to anæsthesia by Sir James Y. Simpson, of Edinburgh, the tide of popular favor ran so strongly in favor of this anæsthetic that it rapidly took the place of all others, while anæsthesia was yet a novelty. Hence by far the largest proportion of the experience in anæsthesia has accumulated from the use of this agent. Within the past two years there has been a reaction in this country in favor of the safer anæsthetics, and it is the primary and almost the only object of this paper to favor this reaction which now tends to give to each anæsthetic its proper place in anæsthesia. At one time chloroform was

almost as exclusively used in this country as in Great Britain. Now, however, it is probably used in more than half the cases, or at least as often as all other anæsthetics together. Various mixtures of chloroform and alcohol, and chloroform and ether, may be used in a twentieth part of the total cases, and nitrous oxide in another twentieth, while ether alone may be used in four-tenths of the total cases. These proportions should be, and probably will ultimately be, so far reversed that ether will be used in six-tenths of the cases, nitrous oxide in three-tenths, and chloroform in one-tenth of the cases to which these three agents are applied.

Nitrous oxide was the first anæsthetic; and the safety and certainty of its effects, even in inexperienced hands, for all momentary operations, and the promptness with which persons recover from its use, render it perhaps the most important of all anæsthetics, because destined to relieve a greater aggregate amount of pain with greater safety than any other agent.

Its practical application to dental surgery by Horace Wells, of Hartford, Connecticut, in December, 1844, was the commencement of anæsthesia; and hence, in the opinion of this writer, Horace Wells is in every good practical sense the discoverer of anæsthesia, and deserves both the honor and the reward.

Upon the general principles above mentioned it is very certain that any agent capable of producing anæsthesia is capable of causing death, and is therefore dangerous; and nitrous oxide has doubtless caused death by its primary influence. But this is so very rare in the many thousands of cases in which it has been used that its record of comparative safety is practically complete. The dental profession deserve the credit of all that has been done in the way of utilizing the advantages of nitrous oxide. After the reverses of Horace Wells, it was not until the notoriety and fashion of using ether and chloroform had worn off the novelty through many years that the use of nitrous oxide began to revive; and yet, in the short time during which it has now been popularly used in this country, the number of administrations have so rapidly increased that they can now hardly be less than twenty thousand per annum, but may be much greater, and this almost exclusively in dental

surgery. It is quite time that the medical profession should awake to the practical advantages and applicability of nitrous oxide to the momentary operations of minor surgery. These operations so far outnumber the greater ones that they outweigh them in the aggregate amount of pain involved; and, if the surgeon considers the safety and saving of pain to his patient first, and his own convenience in operating second, he will hesitate before passing over such an agent as nitrous oxide.

It does not appear to be well adapted to any other than momentary operations, chiefly because, to obtain complete anæsthesia from its use, it must be breathed nearly or quite pure, and therefore entirely cuts off the air-supply, and arrests the vital process of oxidation or aëration of blood in the lungs. Under these circumstances, when the store of oxygen which the blood contained at the commencement of the inhalation is exhausted, death must supervene. This being rather a negative than a toxic influence, however, the readmission of air to the lungs very speedily corrects it, provided the narcosis has not progressed so far as to arrest the mechanical movements of respiration or circulation. A patient may doubtless be as effectually drowned by nitrous oxide as by water, and the resuscitation from partial drowning by it involves the same principles of treatment.

The great obstacles to the more general application of nitrous oxide as an anæsthetic are the inconveniences, rather than difficulties, of obtaining, keeping, and administering it; but now under its rapidly-increasing use these obstacles are as rapidly being overcome. If but half the intelligent pains and labor had been expended upon it that have been given to carbonic acid or soda-water, its advantages to mankind would have been better appreciated.

In England the gas is liquefied by cold and compression, and is offered for sale in small iron bottles arranged with stop-cock, etc., so that the gas is liberated simply by relieving the pressure in the bottle of liquid. The gas is received in bags of india-rubber as wanted, and is administered from these. The enormous pressure of fifty or sixty atmospheres, or about eight or nine hundred pounds to the square inch, is required

to keep it in the liquid state, and this renders it doubtful whether any such plan of using it can ever become generally applicable. Some plan by which it may be held in solution, or be compressed and held under a pressure of say one or two atmospheres, would be much more practical, and will sooner or later be accomplished.

The original apparatus for making and keeping the gas has now, however, been so simplified and so cheapened by the dental profession as to be managed by the most ordinary intelligence. The entire apparatus for making and keeping the gas in quantities of forty and fifty gallons is now sold at the depots for dental supplies at a cost of from forty-five to seventy-five dollars in proportion to the degree of ornamentation, and one pound of nitrate of ammonia, costing about fifty cents, yields from twenty-five to thirty gallons of the gas. An average of about seven gallons of gas is required for complete anæsthesia, and from one to two minutes is commonly necessary to effect this. The anæsthesia is of about one to one and a half minute in duration, and passes off almost entirely in three or four minutes.

It is hardly too much to say that every hospital and dispensary throughout the country should be supplied with this apparatus until a better be devised, and should use this anæsthetic in the large class of cases to which it is appropriate. For a full description of apparatus and mode of managing both the apparatus and the administration, see Thomas's "Manual of the Discovery, Manufacture, and Administration of Nitrous Oxide," published and sold by S. S. White, Philadelphia and New York, price $1.25.

The next anæsthetic in chronological order, but by far the most important of all, is ether, still sometimes improperly called "sulphuric ether" even by those who should know better. The great importance of ether as an anæsthetic lies in the fact that it is the most generally applicable of all, and that it is practically safe in common use. Few doubt the sufficiency of its power to produce complete anæsthesia with practical safety to life in its primary influence, the chief objection to it being the supposed difficulty of application.

And in this difficulty with ether, rather than in any better effect from chloroform, may be found the reason why it does not more rapidly take the place of the more dangerous agent in general practice.

This difficulty in successful application is not real in any sense that should be accepted by an intelligent profession whose skill involves human life, simply because it is surmountable by ordinary average intelligence and skill. The common objections to the use of ether are, that it is slow in its operation; causes a long troublesome stage of excitement; and that after these disadvantages have been submitted to, it often fails to produce a sufficient anæsthesia from any reasonable quantity that may be given. It is not uncommon to see, even in what should be the expert practice of large hospitals, four, six, and even eight fluidounces of ether used in the effort to get patients through the stages of intoxication, and a pound or more is not unfrequently consumed in a single operation. The patient and by-standers, and indeed the whole apartment, become charged with ether-vapor, to such an extent that the air must be nearly explosive, and it is rather remarkable that some accident from fire has not occurred. These efforts often require ten to twelve minutes, and then have to be supplemented by the use of one or more strong men to control the patient's struggles, and enable the operator to get unsatisfactorily through his work within a reasonable time. In not a few cases, the desirable third stage of narcosis is not reached at all.

Now, with all due deference to the well-deserved reputation of many surgeons under whose supervision and control this occurs, it is all due to mismanagement, and is easily avoided.

Dr. John Snow, of London, in his valuable book "On Chloroform and other Anæsthetics," published in 1858, covers the whole ground upon this subject, with an accuracy which time has but served to confirm. He states that the quantity of ether necessary to produce the third stage of narcosis is between four and five fluidrachms in an average of cases; but that, inasmuch as fully one half is thrown back from the lungs, about one fluidounce is usually inhaled by an adult in becoming insensible. He usually placed two fluidounces in his in-

haler, in order to have an excess in store, and this was commonly sufficient if the operation was not unusually protracted. He usually rendered adults insensible in four to five minutes, and children in two to three minutes; and never failed to produce complete insensibility in any one instance, in one hundred and sixty-four applications, which embraced all the great operations of surgery several times. These results were obtained from the use of what is known as "Snow's Inhaler," but which Dr. Snow ascribes to Dr. Francis Sibson, and Mr. Julius Jeffries; and from ether which was at least ten per cent. more dilute than that now in common use in this country for anæsthetic purposes, the specific gravity being 0.735 at 60° Fahr., instead of 0.728 as it should be.

More recent observations, and notably those of Dr. Frederick D. Lente, formerly of Cold Spring, now of New York City, exhibit similar results without a special inhaler. This accurate and skilful observer, and earnest advocate for the general use of ether in anæsthesia, gives some of his experience in the *American Medical Times* for 1862, vol. iv., p. 356, and for 1863, vol. vii., p. 95. The results obtained in this published record were by the use of the cone, extemporaneously formed of coarse towels for each application, and with ether containing not over six or seven per cent. of alcohol and water, s. g. 0.725 to 0.728 at 60° Fahr. The time required to produce anæsthesia, or the third stage of narcosis, the quantity of ether consumed, and the operations for which the anæsthesia was induced, are as follows: 2½ minutes, 1½ (f.) ounce, trephining; 5, 4, 3, and 2½ minutes, 16, 12, 12 and 10 (f.) drachms, four amputations of the thigh; 2 minutes, 7 (f.) drachms, extraction of a ball from the tibia; 4 minutes, 12 (f.) drachms, searching for a ball in the knee-joint; 3 minutes, 16 (f.) drachms, amputation at the knee; 30 seconds, 6 (f.) drachms, incision of an infiltrated scrotum; 70 seconds, 10 (f.) drachms, exsection of the shoulder-joint; 62 seconds, 6 (f.) drachms, exsection of the humerus; 3 minutes, 12 (f.) drachms, counter opening of the knee for the extraction of a ball; 3 minutes, 16 (f.) drachms, searching for a ball in the thigh. Average time for 13 administrations less than 3 minutes, average quantity less than 12 (f.) drachms. The second list published by

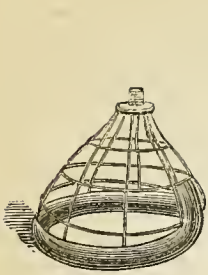

Fig. 1.

Fig. 2.

Fig. 3.

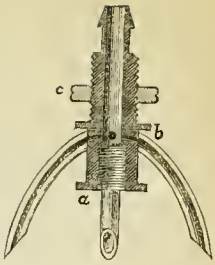

Fig. 4.

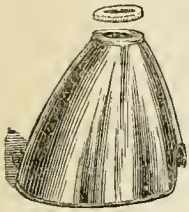

Fig. 5.

Fig. 6.

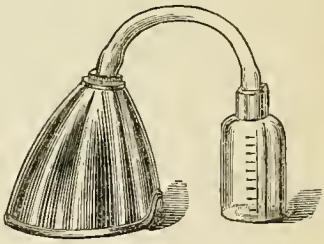

Fig. 7.

Ether Inhaler of Dr. F. D. Lente, of New York City.

Fig. 1. Skeleton of wire with brass nipple at the top, and bound round at the bottom so as to form a cushioned rim for close application to the face, and notched out for the nose.

Fig. 2. A flannel bag to fit over the skeleton frame as far down as the cushioned border.

Fig. 3. A brass mounting to screw on to the nipple of the skeleton frame.

Fig. 4. The same brass mounting, shown in enlarged section, to screw on to the nipple of the skeleton frame by the lower part (*a*). The upper projection is bored out down to *b*, and three equidistant small brass tubes, curved to suit the convexity of the skeleton frame, are made to communicate with the bore internally so as to make a continuous passage from the apex of the nipple to the end of each small tube.

Fig. 5. An impervious cover of tin notched out for the nose, which is put on over the brass mounting, and held in place by a screw-collar (*c*), Fig. 4.

Fig. 6. An ordinary phial of about four fluidounces' capacity, marked in divisions of half a fluidounce, with a horn cap and nipple cemented on to the mouth and neck.

Fig. 7. The complete inhaler ready for use; the face-piece and bottle connected from their respective nipples by a short piece of india-rubber tubing.

Dr. Lente embraces 32 complete cases, a large proportion of which are for minor operations (9 for tooth extraction), in which the average time was but little over 3 minutes, and the average quantity less than 9½ fluidrachms. Subsequent to this experience this same observer devised an inhaler, which for simplicity of construction and management, and for effectiveness and economy in results, leaves very little to be desired. The description and cut of this instrument, which are reproduced here, are copied from the *Medical Record*, for May 1, 1866, vol. i., p. 114.

"It consists, first, of a light wire, helmet-shaped frame-work, Fig. 1, so formed at the base, which is bound with a soft cushion, as to fit over the nose and chin, but not to cover the eyes. At the apex of this cone is a small screw; over this frame-work is a cone of double flannel, Fig. 2, a hole at its apex allowing it to slip over the screw. Over this is screwed an arrangement, shown of proportionate size by Fig. 3, and in enlarged section by Fig. 4, consisting of a short tube about half an inch in diameter, and branching into three small tubes, so arranged, when adjusted, as to embrace and open upon the flannel cone at equal distances from each other, at about one-third of the height of the cone. Over this tube is slipped a cone of tin, or of some impervious material, Fig. 5, not easily acted on by ether. This cover is kept in place by a nut screwing over the tube; over the end of the latter is drawn a rubber tube about half an inch in diameter, the other end of which is to be slipped over the neck of a suitable bottle, containing about four ounces of ether, as soon as the inhaler is required for use; or over the end of a metal tube fitted to a cork which may be attached to any bottle, but the other mode of connection is the safer.

"Having explained to the patient the manner of breathing, viz., to inhale as *rapidly and fully* as possible, as long as he retains consciousness, and *not to be alarmed* at any unpleasant sensations which may be excited at first, the cone is fitted as accurately as possible to the face; the wire and tin being bent a trifle if necessary; and, as a *sine qua non* of the successful use of the instrument, I insist that, having been once placed

on the face, it is to be kept *closely* applied, and never once removed ever so little, until anæsthesia is complete."

This description is followed by details of the application and advantages of the inhaler, and remarks on the use of ether, which may be referred to with advantage. This instrument, under the title of Dr. Lente's Inhaler, may be had of the New York surgical-instrument makers.

Still later, Dr. D. H. Goodwillie, of New York City, published in the *Medical Record*, for December 2, 1867, vol. ii., p. 453, an account of an inhaler devised by him, wherein a two-way stop-cock enables the manipulator to regulate, and alter from time to time, the proportions of any anæsthetic vapor and the air in the inspired mixture. This inhaler is patented, however, and therefore does not deserve professional consideration.

The small experience of the writer, which is unenumerated, and therefore hardly worth mentioning, is less favorable than that of Dr. Snow and Dr. Lente. The average time may perhaps be safely estimated at 6 minutes, and the quantity of ether at 12 fluidrachms to produce anæsthesia, and 16 to 18 fluidrachms as the average total quantity for operations, excluding those which require less than two minutes. This is mentioned not as the result of expert skill with a good inhaler, but of ordinary intelligence and common-sense, with a simple home-made contrivance, to be referred to hereafter.

Dr. Snow states that ether is required in eight or ten times the quantity that chloroform is, but that, as ether anæsthesia is more persistent than that by chloroform, and easier maintained, the disproportion in quantity is reduced in proportion to the duration of the anæsthesia. Dr. Snow also states that the proportion of chloroform vapor in the inspired air should be from four to five per cent., but with ether the proportion of vapor must be about thirty per cent. to secure anæsthesia within a convenient time. Time and experience have abundantly confirmed these statements, with the very important addition that, while this proportion of chloroform vapor cannot be greatly exceeded without largely multiplying the risks, the proportion of ether vapor may be exceeded very far, even to approaching asphyxia by exclusion of air, with comparatively small risk.

The difficulty with chloroform is, to secure a sufficient and uniform dilution of the vapor inhaled, but with ether the difficulty is to secure a sufficient concentration, or, what is the same thing, to prevent undue dilution. Both agents will occasionally suddenly suspend the respiratory movements, but while the circulation continues these are restored by new vital power. Chloroform, however, and chloroform alone, is liable to suspend the heart's action, and when this occurs suddenly and completely the source of vital power is cut off, and the danger becomes extreme. The vapor of either agent may be so administered as to produce only excitement and intoxication; or may be so administered as to cause death by asphyxia, as in drowning. Neither vapor is irrespirable; that is, the vapors do not cause spasmodic closure of the glottis, and this perhaps chiefly because their primary effect is to anæsthetize the lining membrane of the air-passages beyond the power of responding to their irritant effect. Hence, reflex action being thus suspended by the local anæsthesia, there is no natural or organic control to the introduction of the vapors, as in the case of vapors which are irrespirable; but, so long as the mechanical act of respiration continues, the manipulator holds the issue of life and death, from this cause, in his hands. This mechanical act of respiration depends for its continuance upon the circulation of aërated blood, and the laws of diffusion of gases and vapors forbid the introduction of these vapors under any ordinary supposable circumstances without some admixture of air. Although possible, it is far less easy to drown patients by exclusion of air with these vapors than with nitrous oxide; and far more easy with ether than with chloroform, because with the latter agent death occurs from its asymmetrical toxic effect long before the effects of exclusion of air are reached in most cases. According to Dr. Snow, when air is saturated with ether vapor at 80° Fahr., one hundred cubic inches of the mixture consists of twenty-nine cubic inches of air and seventy-one cubic inches of ether vapor. With chloroform, under the same conditions, the one hundred cubic inches of the mixture consists of seventy-four cubic inches of air and twenty-six cubic inches of chloroform vapor, the terms being nearly reversed. Hence, if death occurred only by exclusion of air, ether would be nearly three

times more dangerous than chloroform, and nitrous oxide most dangerous of all. This, however, is only the negative side of the question, and when the positive side is stated the case stands very differently; for if death occurred only by symmetrical and regularly-progressive narcosis, the agent having the greatest power in a given quantity of it must be the most dangerous to life. Add to this the fact which experience alone could establish, and which experience has now abundantly established, that the more powerful agent, chloroform, occasionally causes death by an irregularity in its action, an asymmetrical narcosis, which it is impossible to foresee or prevent. The application of ether is, therefore, comparatively safe from symmetrical narcosis; and is absolutely safe from the asymmetrical narcosis to which chloroform is liable. Why, then, does it not more rapidly take the place of the more dangerous agent as the general anæsthetic? The answer is, because it appears inconvenient for prejudiced and unthinking people to procure the inhalation of its vapor in a sufficient state of concentration. When properly managed, if not quite as prompt as chloroform, it is as prompt as any anæsthetic can be to be safe; and as prompt as it need be, or should be, in the production of so grave a pathological condition. The whole question, then, turns on its administration in a state of sufficient concentration, while it is proved to be difficult to get it too much concentrated. This essential point of concentration of the vapor has long been recognized by all who are successful in the use of ether, as indicated in the efforts to get close-fitting cones, sponges, and mouth-pieces, and the uniform directions to press these firmly over the mouth and nose. The closeness of this application, and the pressure necessary to maintain it with any degree of effective uniformity, are serious obstructions to respiration at the same time that a foreign vapor is substituted for a portion of the air. This is commonly submitted to by intelligent patients, so long as reason and self-control are not materially impaired. But when the stage of intoxication overpowers reason, and the organic animal instincts are left uncontrolled, the imperious necessity to breathe brings on that struggling and resistance which so interfere with the success of the continuous administration in many

cases, because the slightest derangement of the apparatus is so liable to cause an over-dilution of the vapor by the external air.

This inconvenience is so prominent in the use of ether, and causes such an enormous waste of the anæsthetic, that the writer has long looked for some simple device, which, by interfering less with the mechanical act of respiration, and confining the vapor better, might prove useful in less intelligent or inexpert hands. To effect the objects in view, the bag so long in successful use with nitrous oxide supplied the essential idea, and it was only necessary to render this pervious to air to a limited extent, and adapt it to the use of a liquid and its vapor, instead of a gas.

Now, it must never be forgotten that the simple cone of towels supplies all that is needed in the hands of Dr. Lente and many others; and that for a still larger class of manipulators Dr. Lente's admirable inhaler will leave nothing to be desired, for it is extremely doubtful whether failure is possible with any moderately-intelligent use of this instrument. And further, it must never be forgotten that success or failure belongs far less to any special mechanical means, than to the knowledge and skill with which these are applied. The value of a billiard-cue to effect its object depends so much upon the experience and skill of the hand and eye that use it, that without the skill it is but a stick in the wrong place. The inventor of an admirable mechanical contrivance (Mr. R. Dudgeon, the inventor of the hydraulic jack) was beset for directions how to apply the machine. After spending much time and labor in specific replies, his experience taught him that this was, in a large proportion of cases, wasted. So he abbreviated this labor, and told his correspondents that, although he might sell them the very finest fiddle and bow, the sending them the very best instruction-book in the world would not supply the place of brains in learning how to play the fiddle.

It may be safely said that apparatus never succeeds in any thing. All it can do is to supplement the amount of intelligence with which it is applied; while in apparatus generally ingenuity often conceals a want of practical utility.

The simple apparatus for administering ether vapor, now to

be alluded to, was first made and used by the writer about a year and a half ago, and it has been distributed to various persons for trial since that time. In a few hands it has been moderately successful, and is retained in use with supposed advantage. In others it was successful at first, as a novelty, but was soon discarded for the older sponge or cone of towels. In others it was used with partial success, but needed improvements which could only be made at the expense of simplicity and cheapness. In others it was entirely unsuccessful; while some have not reported their results, and it is fair to consider such as being unfavorable. In Bellevue Hospital, where, for many years, ether has been exclusively and largely used, although it was explained and applied there by the writer, it utterly failed in gaining any favor at all, and was soon laid aside in favor of the simple cone of towels, with which, and commercial ether, the best results seem to be obtained. In another hospital it had better success, and is in practical use.

The average drift of all this testimony makes it somewhat doubtful whether it is worth describing, but one point induces the writer to give it the benefit of the doubt, and that is the almost unanimous testimony to its economy in the use of ether in proportion to the effect obtained. This, in connection with the admitted fact that it will accomplish the object, will justify any one who is at all dissatisfied with other modes of administration in giving it a fair trial. Half a dozen of them are herewith offered for trial to any who will accept them, and from these they may be home-made almost without expense. The surgical-instrument makers will, of course, soon furnish them at a trifling cost should they be demanded.

As shown in the adjoining sketch, the apparatus consists of an hour-glass-shaped muslin bag, Fig. 1, which, when laid flat, is about twenty inches long by nine inches wide at the widest part, one end of which is cut off so as to be funnel shaped, and open to receive the lower part of the face. This funnel-shaped mouth of the bag is of such a size as to admit the nose, mouth, chin, and beard of an adult male, and may be adapted to any smaller face by turning it back like a cuff, as in Fig. 4. The muslin of this end of the bag is double, to afford additional obstruction here to the passage of air and ether vapor.

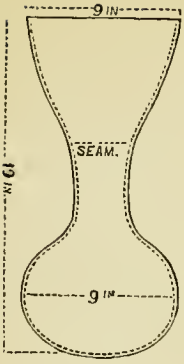

Fig. 1.

Fig. 2.

Fig. 3.

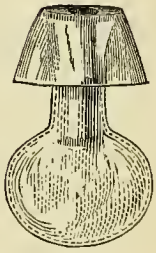

Fig. 4.

Bag for Ether Anæsthesia.

Fig. 1. Size and shape of thick muslin, two pieces of which stitched together by "pudding-bag seam" all round, excepting the straight top or mouth of the bag, the muslin of each piece being double at the upper part (*a*).

Fig. 2. Tin tube two inches in diameter by seven inches long, the edge of the tin being turned in instead of out at the ends, so as to offer an obstruction to the falling out of the roll after it is slipped into place.

Fig. 3. A piece of flannel laid on a piece of stiff blotting-paper or blotting-board, each about six and a half inches wide by eighteen inches long, and the two rolled up together so as to slip easily into the tin tube.

Fig. 4. The bag in readiness for application to a child. That is, with the upper double part turned back like a cuff, so as to allow the chin, nose, and mouth, to occupy a narrower portion of the bag. The tin tube is slipped farther through, into the round part of the bag.

The narrow part of the bag is made elongated, so as to receive a tin tube, Fig. 2, about seven inches long and two inches in diameter. And the bottom of the bag or round end is made of such a size that, when moderately distended, it holds say forty or fifty cubic inches, or more than is necessary for a full inspiration. When about to be used, this bag is thoroughly wetted in water, and squeezed so that it does not drip, for the purpose of rendering it only partially pervious to air and ether vapor. It is not certain that an impervious bag would not answer as well, but it would be more difficult to obtain, more expensive, less cleanly, and, perhaps, less safe. The sole object of the tin tube is to keep the narrow portion of the bag distended while in use. A piece of flannel about six and a half inches wide and eighteen inches long, and a piece of thick blotting-paper or blotting-card of the same size as the flannel, completes the apparatus. The flannel is laid upon the blotting-board, and the two are rolled up together, Fig. 3, into a roll or spiral which will slip into the tin tube, and when there spring out sufficiently to retain its place loosely. A two-ounce graduated measure, and a can or bottle of ether, are all that are now required for the anæsthesia.

The patient to be anæsthetized being fasting, takes, about fifteen minutes before the time set for operation, a fluidounce or a fluidounce and a half of brandy or whiskey, if an adult male, or two fluidounces of wine if a female. This, upon an empty stomach, will produce slight intoxication in about ten minutes, and the anæsthetic has only to supplement this in order to get quickly through the stage of excitement in many cases. It also renders retching less likely to occur. The patient is then placed quietly on the table, and is advised, in a slow, quiet tone, to be composed and perfectly still. He is told that he will soon begin to feel intoxicated, or excited and restless; that this is very much under his control, and that the more he resists it the sooner he will be asleep. If this advice be given with tact and skill, it will be well received, and be of service in a majority of cases. The manipulator is then to wet the bag thoroughly, squeeze out the water till it no longer drips, slip the empty tin tube into its place in the narrow part

of the wet bag, and then prepare the charge of ether. This may be done in several ways; but perhaps the best way is to pour the measured quantity of ether into a tumbler, and, having allowed the roll of flannel and blotting-board to expand itself to nearly the size for the tin tube, dip first one end and then the other into the ether until the ether is all taken up, and then at once slip the charged roll into its place in the tin tube, the latter being already in its place in the wet bag. Then fold, first one end of the wet bag and then the other, up over the part which holds the tin tube so that both ends of the tin tube may be closed up by the wet muslin to prevent loss of ether, and then lay it aside ready for use at any moment. The loss of ether, while thus lying ready, is very small—not over a fluidrachm in half an hour. The quantity of ether for the first charge should vary with the estimated sensibility of the patient. For an adult man, one and a half to two fluidounces, and for females and sensitive males one to one and a half fluidounce is sufficient, if the ether be good; for children, a half to one fluidounce. In the anæsthesia of children, and in many exceptional cases, no general rule can be laid down; and, indeed, the circumstances of each case must always modify each application; and yet the following directions may be found more or less applicable, and therefore useful in a large number of instances:

About ten minutes before the time for operation, the bag being thus in readiness, the can or bottle containing the supply of ether is held to the patient's nostrils, and he is asked to smell it strongly at each inspiration for the purpose of getting used to it. This taking the vapor from the can or bottle is continued for one minute or more, according to circumstances, during which time the advice in regard to self-restraint is firmly repeated. This step establishes tolerance or partial anæsthesia of the mucous membrane of the air-passages, and thus avoids some of the coughing and strangling that are liable to occur from the sudden application of concentrated vapor; but it often brings on hysterical symptoms or delirious restlessness pretty promptly, and whenever this occurs the bag is to be at once applied. If the ether be in a tin can, which is always the best and safest containing vessel for it, and this be

only about one-third or half full, the warmth of the hand causes a good supply of vapor, and the early stages are rapidly brought on. At most, but a minute or a minute and a half is occupied by this step, and the manipulator has still about eight minutes to the time set for operation. The bag is then unfolded, laid on the patient's chest, and the open end drawn over the mouth and nose. The redundant size is taken up in a plait by the side of the nose, and folded down so that the wet muslin is closely applied to the skin of the face, and pressed down into the fossæ on each side of the nose. The part which is least likely to lie close, and which therefore requires most attention, is that under the chin. The most convenient place for the manipulator is at the head of the table, whence he can best apply a hand to either side of the patient's face, and thus support the bag in position without much pressure. The thumbs then naturally fall into the fossæ on each side of the nose, while the fingers support the part under the chin, care being taken not to press upon the larynx. If the patient has a beard, it should be wetted to render it less pervious to air, and the bag drawn tightly around it. If the muslin be well wetted, it sticks pretty closely to the skin, where it gets contact, and the beard offers the chief difficulty. It not unfrequently happens that, after a few inspirations of the concentrated vapor, respiration is suspended. When this occurs the bag is removed till it is resumed, the mouth of the bag being simply turned back on to the bag to save waste of ether. As soon as respiration is reëstablished the mouth of the bag is replaced around the nose and mouth. When restless excitement occurs, the mouth of the bag is supported in place by the two hands of the manipulator, but without much force, and with as little resistance to the motions of the patient as possible, and with no obstruction over the mouth or nose, and the bag, under no circumstances, is to be allowed to become loose or drop off during the excited movements. The next accident likely to occur is retching, a certain degree of which may occur without the necessity of disturbing the bag; but, when actual vomiting is imminent, the bag must be momentarily removed. The patient then usually lies quiet, and soon passes into the third or required stage of narcosis, and this

often with a shudder, or slight general convulsion. The pulse, respiration, and color of the surface, being watched throughout, the eye or the roots of the nails are from time to time tried, to ascertain the condition as to insensibility, and as soon as this is fairly established the operation is begun. In a large proportion of cases not more than four of the eight minutes will have been consumed; and where neither arrest of respiration nor retching occurs not more than two or three minutes' application of the bag will be required. When the operation is fairly under way and no sensibility shown, the bag is removed to avoid the fourth, or snoring stage of narcosis, and is only replaced when some very slight sign of sensibility is seen. In a considerable proportion of operations the first charge of ether, if liberal and well managed, is sufficient, for anæsthesia by ether is quite persistent, and easily kept up, or reënforced. If the operation be long, advantage may be taken of one or more of the intervals when the bag is withdrawn, to examine the roll in the tin tube, and judge by the odor whether the supply of ether be nearly exhausted. If the odor of ether be rather feeble, two or three fluidrachms more is poured on to the roll from the measure, without removing the roll from the tube or the tube from the bag, and the mouth of the bag is turned over to prevent waste until it is needed again. A patient may even wince under the knife before it is reapplied, and yet, if there be a fresh supply of ether ready in the bag, a few inspirations will restore him to the desired third stage again. One or two minutes before the operation is complete, the bag may generally be removed entirely and finally. These precautions do much to prevent that supersaturation with ether which tends to the more certain occurrence of prolonged nausea and vomiting which so often introduce septicæmia, and thus cause death. The reaction always bears an important relation to the primary action, and, if this latter be moderate and well managed, the reaction is likely also to be moderate. The longest time during which the writer has kept up anæsthesia by this bag was about sixty-five minutes for a difficult ovariotomy, and in this the total consumption of ether was less than five fluidounces, and the recovery both from the anæsthesia and the operation was good.

If there be a prominent advantage in this apparatus, as the writer believes there is, it is in the entire freedom of the respiratory process. The lower end of the bag rises and falls with the respiration without offering any practical obstruction to the mechanical process. And those who will persevere with it until educated to its use will probably discover other advantages hardly less important.

In concluding the consideration of ether, it may be safely said that those who resort to it after a long use of chloroform, and acquire the little skill necessary to use it well, will have a sense of safety and satisfaction which they never knew before.

Chloroform is the most rapid, the most certain, and the most effective anæsthetic which has been practically applied on a large scale up to the present time. When to these prominent advantages are added the facility and simplicity of its administration, the small quantity required, the facility of getting it of good quality, its non-inflammability, its cheapness, its agreeable odor, and the prejudice in its favor to which all these circumstances will always tend, the key to its popular use is found.

The more prominent of these advantages, however, belong to its excess of power, and this excess of power involves the power to do harm. Therefore, there is another side to the account of chloroform which a long and extensive experience has accumulated against it.

In common use, though perhaps never in expert or skilful use, it occasionally causes death by progressive symmetrical narcosis. But, as this result may be admitted to be within the control of skill and knowledge to prevent it, it is not the most serious disadvantage of chloroform, and the risks it involves might be fairly accepted as being overbalanced by its advantages. But, unfortunately, chloroform occasionally causes death by an asymmetrical narcosis which is beyond human skill and knowledge to foresee or prevent. The sudden and overwhelming narcosis or paralysis of the heart, commonly called cardiac syncope, whether occurring from direct or reflex action of the anæsthetic, is fatal in a large proportion of the

cases in which it occurs, and it occurs with chloroform alone. It is not a question of submitting to these rare accidents or dispensing with anæsthesia altogether; nor as to whether they occur from chloroform or from its impurities, or from want of care in its administration, nor is it a question as to whether they occur once in five hundred and twenty-five administrations or once in forty thousand administrations. But the simple fact that they occur at all with this anæsthetic, while they do not occur in the use of other anæsthetics which are in practical successful use, and always easily attainable, ought to be sufficient to limit the use of chloroform to the comparatively few cases to which other agents are not applicable.

The fatal accidents from chloroform appear to increase in proportion to the number of administrations very rapidly as it becomes more generally used.

In the *Westminster Review*, for January, 1859, when chloroform had been in use more than ten years, Dr. John Chapman makes a rough though reasonable and useful computation of the proportion of deaths to administrations, and his results are one death in every sixteen thousand administrations. Dr. Sansom states that in the obstetric practice of London it was estimated to have been used forty thousand times without an accident. Dr. Sansom, in 1866, also states that in the French Eastern campaign it was administered thirty thousand times or more without an accident; and in the English Eastern campaign there were but two deaths in an unknown but very large number of administrations. In 1865 Dr. Anstee, of London, had administered chloroform more than three thousand times without an accident. And about this time Dr. Richardson makes a *résumé* from the records of eight large British hospitals, and reports one death in seventeen thousand administrations. Now, however, this same well-informed author, in a paper "On General Anæsthesia and Anæsthetics," presented to the British Medical Association, in August, 1870, states the general proportion of deaths to administrations as being one in twenty-five hundred, or nearly five times greater within six years. And the chairman of the association, Dr. J. Hughes Bennett, in his remarks upon the paper, thinks the proportion of deaths is greater than this. The

causes of this rapid increase can only be surmised. As some recent reports of London hospitals—notably that of Mr. C. Bader, of Guy's Hospital, three thousand two hundred and twenty-four administrations and no death—do not show a very muuch increased mortality, it is fair to infer that the largest share of the increase must fall with the greater force upon the widely-extended general popular use, where want of care and skill, and bad chloroform, may both be involved as important elements. As bearing upon this point, the writer may cite from a private letter from Dr. J. S. Wellford, of Richmond, Virginia, that, in twenty-two thousand administrations of good English chloroform during the late war, no accident occnrred. But, subsequently, the same surgeons were supplied with chloroform from methylated spirit, and during its use had some deaths, although the same care and skill were used.

In this country no general statistics worthy of the name have been or can be obtained; but the deaths which occur are generally reported when in the hands of the regular profession, and generally get into the newspapers or journals through coroners' investigations, or through the keenness of reporters, when they occur in other hands. From this single element each writer has to make his own estimates. Under these circumstances this writer judges that it may be useful to present his estimates and their data, particularly as they are made up from sources not accessible to others. It must, however, be remembered that they are but rough estimates, and each reader must apply his own valuation to the data from which they are made up.

No chloroform has been imported into this country, or exported from it, within several years past, and there are but about four original sources of supply, of which the establishment of the writer is the smallest. Upon consultation with the three other sources of supply, it is found that the total quantity of chloroform sold for consumption in the United States, during 1870, cannot be less than eighty thonsand pounds, though it may be somewhat more. This, and the total number of reported deaths, is all that can be had with any degree of practically useful accuracy. What follows, then,

is simple speculation or rough estimate, though probably safe in the interest of human life.

It may be estimated that not over one-third of this eighty thousand pounds, or say twenty-six thousand pounds, is used for anæsthetic purposes by inhalation. Next, it may be estimated that two avoirdupois ounces, or one and a half fluidounce is used and wasted for each administration, and this would give—

$$26{,}000 \times 8 = 208{,}000, \text{ or say } 200{,}000$$

administrations, as a very extravagantly safe estimate for the whole country during 1870.

By a pretty thorough search through the principal medical journals for 1870, only fifteen deaths can be found reported as having occurred in this country, two of which are equivocal, and one, though probably reported twice, is counted twice. Add to these one death which occurred late in the year, and but just now reported; and one death reported to the writer on hearsay, and which may or may not be among the published cases. This would make a total of seventeen deaths, or one death in eleven thousand seven hundred and sixty-four administrations. But there are undoubtedly a number of deaths from chloroform which escape even the keenness of newspaper reporters, and the number of such is variously estimated. Some estimate that not more than three-fourths of the deaths are published, while others estimate that not more than one-half are ever publicly known. The writer believes the first estimate to be nearest the truth, but adopts the last for safety. This gives thirty-four deaths, or one death in five thousand eight hundred and eighty-two administrations. If any reader judges this estimate to be still not sufficiently liberal, he may double the number of deaths once more, and he will then have one death in twenty-nine hundred administrations, and thus get the mortality up to somewhere near that of Dr. Richardson, for Great Britain. But the writer cannot admit the probability of any such mortality for this country, though he knows of no good reason why it should be so much lower here.

Here, then, is the grave and important probability that

each surgeon, in offering to his patient the anæsthetic advantages of chloroform, offers him in this country one chance in five thousand of sudden death, when he might give him all the benefits of anæsthesia by other agents without the risk.

The writer has neither read of nor heard of a single instance of death or grave symptoms from the use of chloroform when used in obstetrical practice for mitigating the pains of labor nor of any death from its use in controlling puerperal convulsions; but knows of one death where it was given preparatory to the operation of turning in a case where a midwife had mismanaged and protracted a shoulder-presentation. In obstetrical practice it is comparatively rarely given to anæsthesia, but only to intoxication, and this often in the judicious, safe way of smelling the vapor from a bottle held in the hand of the attendant or nurse. And in a large proportion of cases it is only given during the expulsive pains and after dilatation, in small quantities frequently repeated and largely diluted, and given by careful hands. Prolonged experience, however, seems to indicate that some unknown condition in the parturient female renders chloroform less dangerous in obstetrical practice than in general anæsthesia, while its promptness of action renders it peculiarly applicable to the suddenness of these pains. It is also the only agent that can be effectively used in puerperal eclampsia, and in this affection has doubtless saved many valuable lives. In the comparatively small number of cases which are insusceptible to ether it is also applicable, since in all such the want of susceptibility to the less powerful agent would rationally render the more powerful agent safe.

In regard to these tolerant cases, it is very remarkable how much chloroform they may use with impunity. The greatest consumption the writer has ever met with was in a patient of Dr. Gustave Morrelli, of New York City. This patient was the widow of an Italian physician; her age was forty-eight, and her appearance healthy. She was subject to hereditary migratory gout, the sudden pain of which was so severe that she finally gave up all slower means of temporary alleviation for the prompt action of chloroform, and used it habitually for two years or more prior to her return to Europe. Between the

31st of March and the 16th of December, 1865, a record was kept, and during this time, by Dr. Morrelli's direction, she was supplied by the writer with fifty-three pounds of purified chloroform. And Dr. Morrelli stated to the writer that, during her acute attacks, she not unfrequently used two pounds each day, and used it as economically as she could after her long practice.

The writer cannot close a paper on anæsthetics without again referring to his often-published statements, and his long use of the remarkable local and superficial anæsthetic effects of the phenols, or the so-called carbolic acid. The best of these is cresol or cresylic acid, and next phenol or the crystallized carbolic acid. But practically the cheap mixture of the two, called coal-tar creasote or impure carbolic acid, is as good as either. The prompt and complete effect of very dilute aqueous solutions of this creasote upon the pain of burns, erysipelas, etc., led the writer to infer peculiar anæsthetic properties many years ago, and the numbness or insensibility produced upon the hands by handling it confirmed the idea. The same effect in lesser degree is produced by many of the aromatic oils and turpentines, and it is highly probable that most of the liniments and embrocations which have survived the attacks of what is miscalled "rational medicine," owe their continued popular and empirical use to a real local anæsthetic effect produced by this class of substances. The Chinese have long known and used the anæsthetic effects of the essential oils of the mint family of plants, and particularly oil of peppermint, so that it is plain that these old-fashioned local applications for the relief of pain rather deserve more accurate observation and research than the contempt into which they are falling through the fashionable expectantism of the day. The writer can now, in conclusion, only beg the attention of his readers to two important papers recently published on this subject. One by Prof. Erasmus Wilson, of London, on "The Anæsthetic Properties of Carbolic Acid," in the London *Journal of Cutaneous Medicine*, an abstract of which may be found in the *Half-Yearly Abstract of the Medical Sciences*, for January, 1871, at page 93. The other is a paper published