shown in the figure. I also use a mask which covers the mouth and nose. The mouth is closed, and nasal breathing takes place through an orifice in the mask, which is so restricted that step-climbing can just be comfortably carried on in a cool room. The steps are made on and off a box in time with the beats of a metronome. On allowing the rays from a dull red electric fire to fall on the face the step-climbing soon becomes impossible in a sensitive subject through want of air. On switching on a fan, or an incandescent lamp, ease in step-climbing is renewed. The experiment can be carried out with the fire put under the table so as to radiate the bare legs. The screen in front of the fire can then be withdrawn silently by an observer, while the eyes of the subject are kept shut. The eyes should not be covered by a bandage, because this in itself affects the nose of a sensitive subject.

Inhalation of a vaporized adrenaline solution abolishes the reflex "nose-closing" effect. The adrenaline con-

Tracing shows effect on nasal breathing of electric fire, fan, and incandescent lamp. (1) Exposed to electric fire; (2) opened mouth to take a breath, fan then put on, and nasal breathing resumed; (3) fan stopped; (4) incandescent lamp switched on.

stricts the blood vessels, and, preventing vascular congestion of the membrane, keeps the air-way open. The effect of the inhalation lasts for an hour or so. The sensitivity of the skin to the "nose-closing" rays in certain sensitive susceptible subjects is very great. When only one square inch of skin is exposed, and the device is put several feet away, the reflex may result. In a still room at ordinary temperature I was sensitive to the "nose-closing" rays of an electric fire when facing this at a distance of 47 feet, where, of course, no sensation of heat was felt. At a distance of 1 metre from a thermopile the energy of an incandescent lamp was found to be 1/60 of that of an electric fire. When one square inch of skin was exposed at that distance to this fire the "bad" side of my nose became closed; when another and equal area of skin was exposed to the lamp the nose was opened. The latent time in each case was about six seconds. The latent time is much shorter when a large area of skin is exposed; the effect varied as $\sqrt{a.t}$, where a = the area and t = the time. At various distances from the source the effect varies as $\sqrt{i.t}$ where i = intensity and t = time.

Out of sixty-seven subjects recently tested at the London Clinic and Institute of Physical Medicine, fifteen were insensitive, while forty-two showed more or less evidence of the "nose-closing" effect. Asthmatic and catarrhal patients are likely to be more sensitive than others. In all except four of these forty-two the fan made the breathing easier, while twenty-five found it made easier by the incandescent light, and twenty-one by the water bowl.

CONCLUSION

In considering the various baths used for stimulating the skin and producing curative effects, it is of interest to have found evidence of a reflex effect of a striking character. In my case the "nose-closing" effect is accompanied by a slight rise of blood pressure. In regard to heating and ventilating rooms, it is clear that where dark sources of heat are employed there should be adequate ventilation with cool air. This is required not only to produce comfort and a feeling of freshness, but to keep the atmosphere as clean as possible from dust and microbes. Incandescent lamps make such sources pleasanter. Electric fires can be improved by making them brighter sources of heat. A sensitive subject who suffers from nasal catarrh has been improved by replacing in his room a hot-water radiator by a Ferranti bar fire which was made to take 6 amperes. Irradiated with this bright heat he works in comfort with a window open, and has better health. A modern gas fire would have done as well.

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REHALATIONAL ANAESTHESIA

A METHOD OF UTILIZING THE RECENT ADVANCES
IN ANAESTHETIC ADMINISTRATION

BY

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General inhalational anaesthesia to-day is induced and maintained either by one of the modern types of apparatus or by the time-honoured open mask and drop bottle. Apparatus is of the greatest importance in the anaesthesia of modern surgery. In many operations on the head and neck, and in thoracic surgery, it is essential. It is not my object in this article to decry its use, but to try and show those who are called upon to give routine or occasional anaesthetics that, by adopting a combination of methods of administration which have been advocated from time to time, they can secure practically all the very real advantages of the more costly and complex apparatus by a technique which rivals the open mask for simplicity and economy.

The mechanization of anaesthesia is the outcome, to a great extent, of the practical application of the results of recent research, discoveries which cannot be employed when the open mask is used.

RESULTS OF RECENT RESEARCH

Haggard¹ has shown that narcosis depends upon the anaesthetic tension of the agent exhibited, which, in the case of ether, is that concentration of the vapour with which the cells of the central nervous system are in equilibrium. This equilibrium is only reached after gaseous interchanges have taken place, first between the pulmonary blood and the vapour-bearing air entering the lungs, and then between this blood and the tissues. Furthermore, owing to the high absorption quotient of lipid tissue and the volume of blood passing through the central nervous system, this concentration practically equals that of the arterial blood. Thus the rate of absorption depends solely on the amount of ether brought to the blood, and this depends on the volume of respiration. He has shown by experiment that to maintain a state of

surgical anaesthesia the blood must contain 1 to 1.5 grams of ether per litre. This necessitates, during induction, introducing to the lungs 8 to 12 grams of ether per minute. To attain this with ordinary respiratory excursions, which at the commencement of anaesthesia are often rendered shallow by depressant hypnotics, entails the use of a prohibitively strong vapour, a long induction period with gradual saturation of the whole body, or increasing the depth and volume of respiration, so diluting the vapour strength. One gram of ether in one litre of air per minute is as effective for anaesthesia as one gram in five litres per minute.

The work done by Haldane² on carbon dioxide as a respiratory hormone is so well known that a brief reference to his conclusions will suffice. He finds that a rapid induction and termination are essential; the use of re-breathing tends to lessen variations of ether-air composition; and the use of carbon dioxide stabilizes the acid-base balance of the blood, and by stimulating respirations ensures full lung expansion, definitely lessening post-operative complications.

The toxic effects of ether have been the subject of research since 1850. Stephen³ gives a very thorough review of this work, and adds valuable facts from her own investigations. It is admitted that conservatism in the amount of ether used spares the body tissues and metabolism. Ross and Fairlie⁴ quote Gwathmey as laying stress on the necessity of warming the vapour, claiming that "this measure will prevent the loss of heat to the patient incidental to the warming up, in the air passages, of the cold vapour." Shipway and Pembry⁵ show that body heat can definitely be maintained by warm vapour, and Hewer⁶ describes the irritating effect of too hot vapour and the loss of body heat by sweating when it is used.

In considering the open mask, Rowling⁷ has proved clinically that when it is in use the oxygen percentage under it is always reduced and the percentage of carbon dioxide is variable and not maintained. Finally, Flux⁸ has shown that use may be made of the density of anaesthetic vapours, while Miller¹⁰ has gone a step further with his gravitational anaesthesia, showing that this is particularly applicable to ether vapour, nitrous oxide, carbon dioxide, and oxygen, with densities greater than air.

COMPARISON OF METHODS

The salient points, therefore, in our present knowledge of the theory and practice of narcosis are: rapid induction, usually by nitrous oxide and oxygen with carbon dioxide; re-breathing, to warm the vapours and to keep up the carbon dioxide content of the inspired gases with added oxygen; and sufficient warmed ether only to saturate the nervous system or as an adjuvant to nitrous oxide. Most forms of apparatus aim at utilizing these facts, and the results obtained by anyone accustomed to the apparatus used are excellent from every point of view—from that of the patient, the surgeon, and the administrator. But gauges and taps are not infallible; they may become refractory at critical moments, or their readings may be incorrect. Also most of the apparatus is costly, and would be employed by many anaesthetists too infrequently to warrant acquisition. Lastly, there is the fact that when apparatus is used the anaesthetist's attention is divided, and the temptation may arise to discard the reactions and minute-to-minute symptomatology of the patient for dial readings.

On the other hand, when an anaesthetic is administered by the open mask, even when carbon dioxide is used owing to the difficulty of controlling respiration, there is a longer induction period with a retarded recovery rate, and a greater tissue saturation is needed before any required level of anaesthesia is attained. Again, from the purely

physical standpoint the method is unscientific, because of the specific gravity of the gases used, and ether vapour as it falls from the mask is often inhaled by all the theatre staff as well as by the patient—a very important point during a full day's work. The almost unavoidable freezing of the gauze of the mask, and the constant presence of cold ether vapour and droplets in close approximation to the patient's face, are further disadvantages of the open mask method.

APPARATUS AND TECHNIQUE

During the past two years I have evolved a technique which I believe has a very definite position in routine anaesthesia between these two extremes. I have named it rehalational anaesthesia, because it takes its place between perhalation with the ordinary mask and re-breathing into a bag.

The "apparatus," at its simplest, consists of a small cylinder of oxygen and a "J" size carbon dioxide sparklet, which are strapped together, tubes from which are brought to a Y-piece, whence a further tube leads the gases to the mask; a four-ounce ether drop bottle with a Bellamy Gardner dropper, the delivery pipe of which is nipped up so that it will deliver an even drop in any position; and a modified Ogston mask, a short description of which was published in the *British Medical Journal* in April, 1930.¹¹ Two slight modifications have been made since then; first a section of motor car inner tube is slipped over the frame and takes the place of the towel or lint which Ogston suggested, and secondly, a short length of metal tube is clipped to one of the uprights, as indicated in the sketch, and the

Section of mask made up, indicating lead-in tube.

gases are, by this means, led to the depths of the mask. In use the mask is made up, the gas tube attached, and induction commenced.

INDUCTION

Ether, chloroform and ether mixture, or ethyl chloride, can be employed. The most pleasant, however, is nitrous oxide; when this is used an extra gas tube fitted to the mask is advantageous. If plain ether is chosen a few drops are allowed to fall, not on the dome of the gauze, but at the side away from the direct line of the mouth and nose, while the mask is gradually lowered on to the two thick layers of gamgee covering the patient's face. The dropping is slow, and if any gagging or signs of discomfort appear the mask must be lifted momentarily. Before the mask is quite lowered the carbon dioxide is turned on so that the gas just flows, gauged by the hiss in the tube. The breathing deepens, and it is found that a steady increase in drop rate is comfortably tolerated until the patient passes rapidly and quietly into surgical anaesthesia. Very deep breathing before this stage must be avoided; it will cause a sense of suffocation, and increase any tendency to cyanosis. If these conditions do appear there is no necessity to shut off the gas; it is sufficient to raise the mask slightly for a few seconds.

In the case of mixture induction for patients who are not morphinized, seven parts of ether to one of chloroform has proved the most satisfactory. The chloroform helps to mask the pungency of the ether, and it will rarely be found necessary to use the sparklet at all, enough carbon dioxide being retained inside the mask chamber from the patient's own expirations. A regular drop is maintained until steadiness and increased depth of respiration denotes the establishment of anaesthesia; 1 to 1½ drams is usually sufficient for this. A change is then made to pure ether, any gagging or breath-holding being immediately dealt with by means of the sparklet.

With ethyl chloride a very rapid induction is secured by dropping 3 to 5 c.cm. gradually on the mask, and as soon as stertorous breathing denotes full anaesthesia sufficient ether is used to ensure that the whole of the gauze is moist. Any respiratory irregularity exhibited as the patient comes from deep ethyl chloride to light ether anaesthesia can be dealt with by the sparklet.

In nitrous oxide induction a second tube is led from the gas cylinder to the mask, the gas is turned just on, the mask is lowered slowly, and as the stertorous breathing and characteristic dusky colour of this anaesthesia begin to show a few breaths of carbon dioxide are given, the nitrous oxide is disconnected, and an increasing ether drop is commenced, until surgical anaesthesia is attained. A little practice is perhaps necessary with this method of inducing narcosis, for care must be taken that nitrous oxide anaesthesia is not pushed to the "jactitation" stage, when respiratory cessation bars further progress. Should this occur it can be corrected by a few breaths from the oxygen cylinder.

Whatever form of induction is used the anaesthetic room should be kept quiet, and no adjustment of dressings and clothes is permissible until full narcosis is reached. Much will be added to the confidence of patients and to the alleviation of fear by a short preliminary conversation as to how easily they will fall asleep, and since the auditory sense is one of the last to be abolished—a fact often overlooked—this reassurance with simple directions as to their conduct should be kept up until consciousness is lost. This is probably better than the practice of "counting," which, in my opinion, tends to have the opposite effect. Finally, as soon as the jaw muscles permit, an airway is inserted.

Maintenance

With anaesthesia fully established the carbon dioxide is turned off; the patient is evolving and rebreathing his own carbon dioxide from the mask chamber. Respirations are deep and full, and there is a slight tendency to cyanosis; sufficient oxygen is turned on to counteract this. It will be found that ether can now be dropped almost as sparingly as chloroform. No freezing of the gauze will take place, provided the drops are not directed constantly to one portion of the mask. In actual practice, unless a deep level of anaesthesia is required, when the whole of the gauze is moist, the drops should be directed to the sides of the mask.

With this form of administration two further important points must be borne in mind. First, a constant and regular ether dropping is essential; secondly, since deep levels of anaesthesia are reached much more rapidly than in open administration, the difficulty to those experienced only in that method will not be so much in keeping the patient deep, as in allowing him to ascend to lighter levels.

Recovery

Following the final deepening of anaesthesia to facilitate the closure of the peritoneum, the ether dropping can be discontinued. Thus, by the time the surgeon is closing

superficial tissues no ether remains on the mask. Six full breaths of carbon dioxide are given from the sparklet, and the patient is allowed to inhale, with the resultant increased respiration, an atmosphere rich in oxygen for the remainder of the time he is on the table. After an abdominal operation of the average length, when atropine only has been used in premedication, the patient leaves the theatre phonating with his essential reflexes present, and is usually awake in a further sixty to ninety minutes. In the presence of morphine, however, the final recovery is delayed.

It is appropriate to indicate here further simple additions to technique which may be made with advantage. In gall-bladder surgery of the obese, and in cases where an abnormal posture is required, the introduction as an airway of a pernasal endotracheal catheter, as advocated by McGill,¹² will simplify administration, giving an even greater control of the patient and rendering the operating field less disturbed by excessive respiratory excursions. The use of a simple vaporizing apparatus—such as that of Shipway or of Howard Jones—to replace the drop bottle is a further refinement. Some form of flow-meter may be introduced into the gas circuit, if accurate measurement of the gases is considered desirable.

RATIONALE AND ADVANTAGES

What benefits accrue from this technique, and how are they brought about? Use is made of all Henderson's tenets for a good anaesthesia. Because of the arrangement of partial rebreathing, a more constant air mixture is maintained in the lung, and this, assisted by the addition of carbon dioxide, ensures a constantly quiet induction in every type of case, with very little experience on the part of the administrator. Because of the form of the mask, every drop of ether is warmed and vaporized by the patient's own efforts, the vapour being concentrated to him alone, thus protecting the anaesthetist, the operator, and the theatre staff.

The usual amount of ether used, from induction to termination, for an adult male undergoing an upper abdominal operation lasting from forty to sixty minutes is six ounces—rarely more, often less. From this it will be seen that patients anaesthetized by this method are a totally different proposition to those anaesthetized by the open mask. In the latter, owing to the uncontrolled respiratory excursions, deepening of anaesthesia is only secured by the exhibition of a very strong vapour with all it entails—wet and frozen gauze, and the use of excessive quantities of ether, etc.—so that the whole organism is soaked with the drug, and the venous return to the lungs carries sufficient absorbed vapour with it to aid in the building up of the required concentration in the arterial blood. This, in its turn, results in a slow return to lighter anaesthesia and subsequent recovery, and because of the toxicity of ether there is the danger of interference with the metabolism and damage to the body cells.

On the other hand, with rehalational anaesthesia, although the concentration in the arterial blood must be the same, it is secured much more rapidly by slightly increasing the vapour strength inhaled by the controlled respirations. Should this be insufficient to give the depth of anaesthesia required, the respirations, and therefore the concentration, can further be increased by the use of the sparklet. When the need for deep anaesthesia passes, if the ether dropping ceases, recovery is as rapid, for the converse of Haggard's findings holds good, and the elimination of ether depends upon the volume of respiration. Thus, by directing the drug practically wholly to the central nervous system, an identical degree of anaesthesia can be attained without exposing the rest of the body to toxic doses of ether.

Again, post-operative vomiting and acidosis are diminished. Three main factors are at present advanced for the causation of these conditions: (1) the psychological factor; (2) disturbance of the pH of the blood; (3) an initial tendency of some patients to ketosis. The preliminary conversation does much to remove any psychic causes, while the constant inhalation of an atmosphere containing sufficient carbon dioxide, yet rich in oxygen, tends to keep the acid-base balance of the blood near normal both during and after operation. This is of great assistance in lessening the third causal factor, especially if the existence of the condition has been recognized before operation and suitable treatment given.

The lungs are more fully expanded both during and immediately after operation, and the incidence of post-operative chest troubles is greatly lessened. Gas pains, too, are not so frequent after anaesthesia by this method. Wilson¹³ has shown that carbon dioxide stimulates peristalsis, and I can bear this out by my own observations. Finally, the patient is the sole indicator of the progress of anaesthesia. The administrator, therefore, must of necessity "keep his eyes in the boat."

CONCLUSIONS

1. The understanding of the phenomena of narcosis with their causation has greatly advanced in the last few years.

2. Anaesthetic apparatus has a very real role in modern surgery, and makes full use of recent knowledge, but by combining several well-tried "tricks" into a simple technique a form of administration has been evolved which embodies the important advantages of mechanized anaesthesia with the ease in use of the open mask method.

3. Induction is simplified and made tolerable. A uniform, well-controlled operating field is assured in any type of case, and operative and post-operative dangers are greatly minimized.

4. The method depends only on facts; the actual technique can therefore be varied infinitely to suit the individual requirements of any anaesthetist.

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A CASE OF COMBINED SCLEROSIS WITHOUT ANAEMIA TREATED BY INTENSIVE IRON THERAPY

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INTRODUCTION

Dr. Sargent's work in investigating and treating a number of cases of combined sclerosis has been largely under my observation, and his treatment of these cases with massive doses of iron, with or without the usual liver therapy, is, in my opinion, a most important advance in neurological therapeutics. The coincidence of subacute combined degeneration of the spinal cord in association with a grave anaemia, pernicious in type, has been known since Lichtheim's publications in 1887 and, more definitely, since the arresting paper in *Brain* by Russell, Batten, and Collier in 1900, but increasing experience shows that the same nervous phenomena occur at times with a normal blood picture. More constant even than anaemia in this disease is complete achlorhydria, as revealed by a fractional test meal, even though digestion and appetite are apparently normal. This evidence of achlorhydria is a valuable point in differential diagnosis from tabes, disseminated sclerosis, and toxic polyneuritis, which are the diseases most likely to be confounded with combined sclerosis, and it is now possible to recognize this condition at an earlier stage than formerly, which is naturally of the utmost importance if cure by therapeutics is available.

Paraesthesiae and tinglings, or "electric" sensations in the hands and feet, with areas of numbness of the extremities, sometimes amounting to severe pains in the

limbs and back, and followed by unsteadiness of gait, are, if accompanied by achlorhydria, diagnostic of subacute combined degeneration, even in the absence of anaemia and spastic phenomena such as ankle-clonus, extensor plantar reflexes, and sphincter weakness.

I have had under treatment by massive iron therapy several cases of subacute combined disease, some exhibiting the full clinical picture of a megalocytic anaemia with ataxic paraplegic symptoms, two others with the paraesthesiae and pains which I have described, associated with ataxia without spasticity and with achlorhydria and pernicious anaemia, and two others in whom the blood picture was normal, although there was marked spastic paralysis and achlorhydria. In all these cases, without exception, the improvement after a few weeks of the treatment was very marked, the pains and numbness disappearing, and the weakness and ataxia steadily improving. The two cases with normal blood pictures were treated with Bland's pill only, 150 grains daily, without any liver therapy. It would appear, therefore, that the nervous degeneration in the spinal cord is in some way dependent upon deficient iron metabolism, which again may be in part associated with achlorhydria. Though the latter would appear to be constant in subacute combined degeneration, its presence does not necessarily set up faulty iron metabolism, since apparent normal health for years may be compatible with complete achlorhydria; some hitherto unrecognized factor must also be concerned in the iron deficiency and the consequent nervous degeneration.

W. H.

It has been suggested in recently published work that faulty iron metabolism is responsible for the nervous degeneration met with in anaemia, both Addisonian and non-Addisonian in type.^{1,2} In the neurological picture obvious improvement was observed after very large doses of iron had been administered in the form of Bland's pill, 150 grains a day. The improvements recorded have now lasted for periods of over a year.

Our observations have led us to concur with the view that the anaemia itself plays no part in the causation.