NOTES ON THE ADMINISTRATION OF ETHER BY THE PERHALATION METHOD.*

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Ether as given on an open mask will work satisfactorily with children and debilitated adults, but when it comes to dealing with young and vigorous adults of both sexes, it leaves a good deal to be desired.

During the induction period, and to a lesser extent in the maintenance of anaesthesia, it leads to the use of excessive quantities of ether, and even then it may not be possible to get and keep the patient properly under.

The reason for this difficulty in getting the patient under with the open mask is that the percentage of ether vapour obtainable from a gauze covered mask is insufficient to anaesthetize a strong healthy adult. According to the experiments of Hewitt and Syme, the maximum percentage of ether vapour obtainable from a gauze covered mask is about 14, while Connell has shown that 18 per cent., and in some cases more, is required to produce anaesthesia in an adult. In order to get a sufficiently strong percentage of ether vapour from the gauze mask, we must take advantage of certain of the physical properties of ether. Ether vapour is very mobile, and is about 2½ times as heavy as air, and in consequence of this falls very rapidly.

Consider for a moment what happens when ether is given on a gauze mask. During inspiration air is drawn in through the gauze, and in its passage through the gauze takes up, say, 14 per cent. of ether. During expiration, air is blown outward through the gauze, and takes up a percentage of ether.

* These notes on Perhalation Ether were read to the Society of Scottish Anaesthetists.
probably higher than that taken up during inspiration, as the expired air is warmer. The ether blown out of the gauze is lost, so far as helping to produce anaesthesia is concerned, as, owing to the mobility and weight of the ether vapour, it has fallen below the level of the mask before the next inspiration. That this is so is shown by the following facts:

1. If the hand be laid dorsum up on the patient's pillow close to his head, during expiration cool ether vapour will be felt falling on the hand, though it is well out of the line of the patient's breath.

2. If the gauze be watched during expiration, ether vapour will be seen rising as a white cloud for a short distance above the mask and immediately pouring rapidly down the sides of the mask and the patient's head. This white cloud is only to be seen if the air of the room is cool and moist. If the air is warm and dry, there is no white cloud, but the ether vapour can be seen falling as its refractive index is different from that of air, in the same way as the white cloud.

3. If the anaesthetist, after the administration has gone on for a short time, will bend down and place his face almost touching the pillow and close to the patient's head, he will find that the atmosphere there is unpleasantly strong with ether, whereas if he will keep his head higher than the patient's, he will suffer no inconvenience.

The behaviour of ether vapour can be more thoroughly and conveniently studied by means of an experimental mask, consisting of an ordinary metal funnel, to the large end of which a wire frame is attached, over which a number of layers of gauze can be stretched and secured by a rubber band. To the small end of the funnel a rubber tube three feet long is attached. If ether is poured on the gauze and the experimenter blows through the rubber tube attached to the small end, all the phenomena above mentioned can be closely observed. It will be seen that the ether vapour rises only a very short distance above the gauze. If the experimenter blows gently so as to imitate quiet expiration, the distance will be less than half an inch, often not more than a quarter
of an inch, and even with forcible blowing not much more. A lighted taper may be held within an inch of the top of the gauze and the ether will not ignite, but if it is held below the mask it immediately catches fire. This shows that the risk of fire from ether vapour is much greater if the fire or light be at a lower level than the head of the patient. There is very little risk of fire from a lamp or gaslight, provided it is above the level of the patient's head. It will be observed that the ether vapour falls very rapidly downwards and clings very closely to the surface of the gauze, diffusing very little laterally unless disturbed by air currents, and so rapidly that before the next inspiration practically the whole of it will have fallen below the level of the mask. One point is emphasized, namely, that the dome-shape of the ordinary mask is a particularly bad shape so far as conserving any of the expired ether is concerned, as the ether falls so readily down its sloping sides, and that the ordinary mask would be much more efficient if it were turned upside down, i.e., with the concavity upwards. The vapours of chloroform and ethyl chloride may be studied by means of the experimental mask. It will be found that they behave in the same way as ether, rising only a short distance above the gauze, and then falling quickly downwards.

If a glass cylinder of sufficiently large diameter to fit the experimental mask be placed upon it and secured at the bottom with a rubber band so as to make it gas-tight, the upper end of the cylinder being left open, the ether vapour will be seen to rise for a short distance inside the cylinder and immediately sink back again on the gauze, while scarcely any of it can be detected escaping from the open top of the cylinder.

It will be realized from the foregoing facts that probably more than 50 per cent. of the ether dropped on an ordinary mask is wasted, and it is by utilizing this wasted ether that one can get a sufficient percentage of ether to ensure proper control over the patient. What is required is some arrangement which will catch the expired ether vapour and prevent it falling downwards, so that it will be available to augment the percentage of ether in the next inspiration. Probably the best arrangement would be to place a frustum of a cone four
or five inches deep, made from a towel or other suitable material, with its narrow end fitting round the base of the gauze covered mask and its upper wide end open. With the patient lying on his back this would probably catch most of the expired ether vapour, as, owing to the straight path downwards which ether vapour takes, very little would escape over the edge of the frustum. This arrangement, though efficient, is somewhat awkward, and for practical purposes a towel folded four times lengthwise and rolled into a cuff or cylinder with a diameter to fit the base of the mask, is applied over the mask, so that the gauze in the mask lies at the bottom of the cylinder. It will be found that with this arrangement it is much easier to induce anaesthesia than with the ordinary mask, but the drawback is that the towel is very easily displaced. To overcome this difficulty I use a modification of Bellamy Gardner's mask. In this modification the gauze-retaining ring is replaced by one carrying a number of wire uprights about four inches long, these being connected together by another ring at their distal ends. This ring is slightly wider than the retaining ring. To use this mask it is first covered by 12 to 16 layers of gauze and the retaining ring closed, then the folded towel is wound tightly round the upright frame, care being taken that it fits closely at the bottom and secured by a safety pin. A pad of cotton wool, six inches square, with a hole in the centre of it large enough to uncover the patient's mouth and nose, is laid on the patient's face, and the prepared mask placed on it. (The patient should have had a preliminary injection of morphia and atropin.) The administration of ether is then commenced by dropping ether on the gauze at the rate of about one drop every two or three seconds, commencing at the upper end of the gauze, well away from the patient's mouth, then working round the sides. The middle of the gauze, which is immediately over the patient's mouth and nose, should be avoided during the first minute. After that the ether may be dropped on the centre of the gauze. The rate of dropping should be increased as rapidly as the patient will tolerate. The drop bottle should be kept continually on the move so that no two drops may fall on the same spot. The breathing should be closely watched and any holding of the breath,
cough or other sign of discomfort calls for a decrease in the rate of dropping. After a couple of minutes at latest the rate of dropping should be increased sufficiently to get the whole of the gauze thoroughly wet, and it should be kept in this condition during the whole of the induction period. This is a point of great importance, and neglect of it is the chief cause of the difficulty beginners experience in getting the patient under. It is useless to keep one part of the gauze soaked and leave the rest dry, as the evaporating surface is reduced, and with this reduction the percentage of ether in the inspired air is lessened. Continuous dropping, just fast enough to keep the gauze thoroughly wet, is all that is required. It should rarely be necessary to pour ether on. If ether is poured on continuously a great deal of it is wasted, as the gauze acts as a drain and the excess finds its way down to the cotton wool pad which becomes soaked, and as little or no air passes through the wool to the patient, the ether is to a great extent lost so far as helping to anaesthetize the patient is concerned. An excess of ether is apt to cause freezing of the gauze, and once the gauze is frozen the percentage of ether that reaches the patient is reduced to a point lower than can be obtained from the mask kept just thoroughly wet. This is due to the rate of evaporation of ether being reduced by the low temperature, and to the fact that little air will pass through the frozen part of the gauze. It is very important that the administration should be continuous during the induction period, and nothing should be allowed to interfere with this. It is surprising how rapidly a patient comes round if the administration is discontinued during this period. As a rule the patient goes under quietly with little excitement, and in favourable cases anaesthesia is established in from six to ten minutes. If a clear airway can be maintained the patient will go under quietly, but should anything occur to hinder the free ingress of air it usually leads to an increase of secretion and a collection of mucus in the pharynx. This is most likely to occur in strong muscular individuals. The administration should be pushed until the corneal reflex is abolished. After that point is reached caution should be used, as this method is much more powerful than the ordinary method, and it is quite an easy thing to get the patient too
deeply under. The amount of ether given should be reduced, and will vary with different patients. After a little experience it is quite easy to maintain anaesthesia at any desired depth from the lightest to the deepest that is safe.

An alternative method of using the mask, and one that is more pleasant for the patient, is to commence the administration with the mask, prepared as before, upside down, and to drop the ether on the concave surface of the gauze. As the gauze is farther from the patient's face, the ether vapour is better diffused through the air before it reaches him, and consequently is much less irritant. The mask is kept in this position during the first two minutes, and then turned to the ordinary position, and the administration continued as in the first method. With young children it may be advisable to keep the mask in this position during the whole of the administration.

My mask works well with Shipway's warm ether apparatus, and Dr. Fairlie, of Glasgow, informs me that he uses it successfully with Pinson and Wilson's ether bomb.

As a rule from 1 and 1½ ounces to 2 ounces of ether will be required to anaesthetize the patient, 2 ounces more during the first half hour, and 2 ounces for the second half hour.

The important point to keep in mind is that it is only by utilizing the ether vapour blown out of the mask during expiration that it is possible to get a sufficient concentration of ether vapour to ensure complete control of any case. The method I have described is but one way of doing this, and other methods may occur to other anaesthetists, e.g., with a patient lying on his side; an ordinary mask may be used, and a folded towel arranged in front of his face so as to form a reservoir to catch the ether blown out of the mask.

I have recently been trying to apply the principle of my mask to the Clover inhaler by substituting for the rubber bag a metal cylinder open at the top and closed at the bottom. This cylinder is 4 inches high and 3½ inches in diameter. Close to the bottom it has a hole into which a short length of ½ brass tube is soldered. It is attached to the Clover by means of an elbow-piece which is free to rotate on the brass tube, and in the hole in the top of the Clover, so that the cylinder can be always kept in a vertical position. The cylinder acts as a
trap for the ether vapour in the expired air, while the open top allows the patient to have plenty of air. I have found it useful in maintaining anaesthesia in cases where, from the position of the patient, it was inconvenient to use the mask. My experience of it has been too short to say whether it is to be a success or not.

OPEN NITROUS OXIDE-ETHER SEQUENCE.

In order to reduce the length of the induction period and to make it more pleasant for the patient, I have been accustomed to commence the administration with nitrous oxide given with the mask I have described by the open method of Flux. With the mask prepared and in position a tube is led from the nitrous oxide cylinder and held just inside the top of the mask. The gas is then turned on and allowed to flow into the mask. Being heavier than air, it rapidly displaces the air inside the mask, and the patient goes under almost as rapidly as when using the ordinary closed method. After eight or ten breaths the patient's breathing gets deeper and steadier and consciousness is lost. At this point the administration of the ether is cautiously commenced. If there is no alteration in the respiration the rate of dropping is quickly increased so as to get the whole of the gauze wet. The colour of the patient is closely watched for the first sign of duskiness. As soon as this appears the flows of nitrous oxide is reduced. When automatic breathing is properly established the gas supply is cut off and the administration continued with ether alone. It is very important to avoid any duskiness or cyanosis, and when any sign of this appears the mask should be lifted, and the patient allowed a breath of air, the amount of nitrous oxide being at the same time reduced. When this sequence is used the patient goes under very quietly with no struggling. The induction period by this method is usually four or five minutes.

The Eastern Society of Anaesthetists meets with the Congress of Surgeons at New York City, Oct. 20—24, and the third annual meeting of the Southern Association of Anaesthetists, in conjunction with the Southern Medical Association, will be held at New Orleans, November 24—27.

B. Mask with gauze only, before towel is pinned round uprights.
A Combined Endo-tracheal Pump and Suction Apparatus.