TRANSPORTABLE APPARATUS FOR HALOTHANE ANAESTHESIA

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SUMMARY

Halothane, like ether, can be administered precisely and effectively with quite simple apparatus, which employs the “draw-over” principle with atmospheric air as the carrier gas. A portable unit is described, which has been designed on these lines for halothane/air anaesthesia, and which provides the anaesthetist with a complete self-contained set of equipment ready for immediate use. The essential features of this unit include a temperature-compensated vaporizer for halothane, a means for accurately and economically supplementing the inspired air with oxygen, and an automatic valve system which allows for both spontaneous and intermittent positive pressure respiration. It is suggested that this apparatus may have a useful role in developing regions, and with the Medical Services of the Armed Forces on active service overseas, and under other conditions when more elaborate apparatus and supplies of nitrous oxide are not readily available.

Although advances and improvements in anaesthesia doubtless owe much to the development of the modern anaesthetic machine with all its present-day complexities, there are still many parts of the world in which nitrous oxide and other compressed anaesthetic gases are not easily available, and there are still occasions when simplicity and portability of apparatus are of necessity overriding considerations. These conditions are encountered typically in developing countries, and by the Medical Services of the Armed Forces on active service overseas, and to some extent even in our own country, in domiciliary midwifery practice for example.

CONSIDERATIONS

In these circumstances, in order to meet the demands of modern surgery, the anaesthetist needs robust and compact equipment, which is not dependent solely for its function on compressed anaesthetic gases, and yet allows for the precise administration of anaesthesia by facepiece or endotracheal tube.

This role has been admirably filled in the past by the EMO Inhaler and the Oxford Inflating Bellows, introduced by Epstein (1956) and Macintosh (1953). These devices together form the basis of a simple unit, which experience has shown can be used with safety and satisfaction for ether anaesthesia, employing atmospheric air as the carrier gas, for almost any surgical operation so far devised for which anaesthesia is indicated.

Nevertheless ether has lost much of its popularity in recent years for reasons which are too well known to repeat, and its place is being taken to a large extent in clinical practice today by the newer fluorinated compounds, notably halothane, which in spite of the recent alarming reports of possible hepatotoxic properties, still enjoys wide approval.

Like ether, halothane is an all-purpose anaesthetic, which can be administered quite effectively with minimum dependence on other drugs by employing the “draw-over” principle of the EMO Inhaler, and a modified version of this apparatus has been designed specifically for use with halothane.

The relatively low boiling point of ether can be an embarrassment in hot climates, its high flammability renders it unacceptable as air freight, and no one can be in doubt about the explosive hazard involved in the use of ether anaesthesia, particularly when supplemented with oxygen. Halothane, of course, is not flammable and its volatility is conveniently low.
The Haloxair Apparatus.

FIG. 1

FIG. 2
The Haloxair Apparatus.
Induction of anaesthesia with halothane is rapid and easy even in the hands of relatively inexperienced anaesthetists; this can scarcely be claimed for ether. Ready controllability of the depth of anaesthesia, prompt recovery, and a reduced incidence of postoperative nausea and vomiting, are further points in favour of halothane, while the reduction of blood loss, a feature of halothane anaesthesia, makes the surgeon's task easier and materially reduces the need for blood transfusion.

There seems, therefore, much to be gained by adapting the principle of the EMO Inhaler and Oxford Inflating Bellows for the administration of halothane instead of ether.

In redesigning apparatus for this purpose, it is not sufficient to merely modify and recalibrate the EMO Inhaler, for a number of reasons:

(i) To do so fails to take advantage of the higher potency of halothane, which allows the vaporizing chamber to be much reduced in size and weight without loss of efficiency; a welcome feature in portable apparatus.

(ii) The respiratory depressant effects of halothane, and of modern anaesthetic techniques involving the use of muscle relaxants, demands facilities for assisting or controlling the patient's respiration. These requirements are best fulfilled by an automatic valve system, which forms an integral part of the apparatus.

(iii) A means of accurately supplementing the inhaled gases with oxygen, when necessary, is generally considered to be an essential feature of any anaesthetic machine. The importance of this in the type of equipment under consideration needs little justification, when it is realized that, under the very conditions in which apparatus of this kind is most valuable, blood for transfusion may be difficult to obtain. The recent work of Freeman (1962), and Nunn and Freeman (1964) emphasizes the value in cases of unrelieved haemorrhage of oxygen enrichment of the inspired gases, irrespective of the anaesthetic agent in use.

REQUIREMENTS

With these considerations in mind, it seems that apparatus for halothane/air/oxygen anaesthesia should conform with the following general specifications:

(i) The vaporizer should be reduced to the smallest size compatible with efficiency and accuracy.

(ii) A "built-in" device should allow for precise supplementation of the inhaled air with oxygen, and at the same time ensure maximum economy in the use of this gas.

(iii) The valve system should be so designed as:

(a) to provide a strictly non-rebreathing circuit;

(b) to permit automatically both active spontaneous respiration and passive intermittent positive pressure pulmonary ventilation.

(iv) Ideally the overall resistance to gas flow through the apparatus should not exceed 12 mm water gauge at a flow rate of 40 l./min.

(v) A reservoir bag should be included in the circuit for assisting or controlling respiration, the movement of which during spontaneous respiration can act as a rough guide to the anaesthetist of the rate and depth of the patient's breathing.

(vi) The apparatus should be mounted with maximum economy of space on a rigid base as one complete gastight unit, and perishable or fragile materials should be avoided in its construction.

(vii) For purposes of transportability, a carrying case should be designed of sufficient strength to give maximum protection to the apparatus, and of sufficient size to accept the apparatus, one lightweight cylinder of oxygen, and all necessary accessories, so as to provide one complete set of equipment ready for immediate use.

THE APPARATUS

Clinical and laboratory trials of prototypes of apparatus designed to meet these requirements have recently been undertaken, and it is the purpose of this article to give a brief description of the final production model, the "Haloxair Apparatus",* as it is now called.

* The Haloxair Apparatus may be obtained from Cyprane Ltd., Keighley, Yorkshire, whose helpful cooperation in the design and manufacture of prototypes has been invaluable.
DESCRIPTION

The apparatus, mounted on a rigid duralium tray, is depicted in figures 1 and 2, and a diagrammatic lay-out is shown in figure 3.

The essential components comprise a halothane vaporizer, a device for the supply and control of supplementary oxygen, a Connell-Macintosh concertina reservoir bag, and an inspiratory and expiratory valve system.

The vaporizer.

The vaporizer E is cylindrical in outline and measures approximately 7.5 cm x 7.5 cm x 19 cm, and weighs 2 kg. It is temperature compensated and is calibrated for delivery of halothane in concentrations of from 0 to 5 per cent. It is stated to be "non-spillable", which in this context means that, if it is accidentally inverted when in use, a sudden excessive concentration of halothane will not be delivered.

Supplementary oxygen.

Supplementary oxygen is supplied through a fine adjustment control valve C, operating a small plastic flowmeter D, which is calibrated for flow rates of from 0 to 3 l./min. (A flow rate of 1 l./min will lead to a minimum of 30 per cent oxygen in the inhaled gases, provided that the patient's minute volume does not exceed 8 l./min.) Oxygen from the flowmeter is introduced into the circuit between the vaporizer E and an "economizer" A, which is simply a baffled rigid reservoir for containing the oxygen flowing during expiration. The base of the flowmeter is connected by means of a length of flexible tubing to a miniature regulator and pressure gauge incorporated with a cylinder yoke for connection to the standard pin-index type of oxygen cylinder valve. A separate adaptor is also supplied so that the yoke can be attached to the bull-nose type of cylinder valve, and other adaptors can be provided for any other type of oxygen cylinder valve. The Macintosh modification of the Connell bag is fitted with a light internal spring, as in the Oxford Inflating Bellows, which allows for appreciable movement of the bag during spontaneous respiration.

Valve system.

The valve system, which consists of three unidirectional valves superimposed upon each other in the vertical plane, is enclosed in a hollow Diakon pillar, which also bears the inspiratory and expiratory ports. Access to the valve chambers for cleaning or replacements can be readily
obtained by removing four threaded bolts, and a screwdriver is provided in the set for this purpose. The principles involved in this system are shown in figure 3 and are described in a later paragraph.

Two standard lengths of concertina tubing connect inspiratory and expiratory ports to a simple metal Y junction piece for further connection to facepiece or endotracheal tube adaptor.

The circuit (fig. 3).

Spontaneous respiration. During inspiration, valve Q closes, and air is drawn in succession through the air inlet B, the economizer A, the vaporizer E, valves G1 and G2, concertina tube L, to the facepiece N. On expiration, valve G2 closes, valve Q opens, and the exhaled gases pass to atmosphere through concertina tube O, valve Q, and the vents P.

Manual ventilation. On raising the bellows of the reservoir bag J, valve G2 closes and air is drawn through inlet B, economizer A, vaporizer E, and valve G1 into the bag. On depression of the bellows, valve G1 closes and the displaced gases pass through valve G2 to the facepiece; at the same time the pressure in the bag is transmitted by way of tube R to the diaphragm T. This depresses the diaphragm, forcing plunger U down on to expiratory valve Q, so as to close it and prevent escape of the gases. In this way provision is automatically made for positive pressure inflation of the patient's lungs by manual depression of the bag. On raising the bellows again valve G2 closes, the pressure is relieved on diaphragm T, valve Q opens and allows free passage of gas from the patient's lungs to atmosphere.

Resistance to respiration.

Utilizing a constant flow rate of air of 40 l./min to simulate peak resistance occurring during average respiration, the overall resistance of the apparatus on the inspiratory side has been found not to exceed 12 mm water gauge with the vaporizer control in positions up to 3. With this control set at 4 and 5, rather higher resistance in the region of 20–25 mm water gauge has been encountered, but this is considered acceptable, as these control positions are unlikely to be used for prolonged periods.

The expiratory resistance is satisfactorily low: at a continuous air flow rate of 40 l./min, it is in the region of 8 mm water gauge.

Carrying case.

For transportability, and to meet the requirements for a comprehensive set of anaesthetic equipment in one unit, a strong but lightweight case has been designed to contain the apparatus and all necessary accessories.

The base of the case has rattleproof compartments for one 72-gallon lightweight oxygen cylinder, one 250-ml bottle of halothane, endotracheal tubes, adaptors, spanners, etc. The lid too has a fitted compartment, which accepts a laryngoscope, airways, endotracheal tube connectors, concertina tubing, facepiece and retaining harness.

The case itself makes a convenient stand for the apparatus when in use (fig. 2). The external dimensions of the case are 24 cm x 54 cm x 33 cm, and its total weight filled amounts to 20 kg.

DISCUSSION

Clinical experience with the apparatus described has shown that it can provide equally satisfactory standards of anaesthesia during induction, maintenance and recovery, as can be obtained with nitrous oxide/oxygen/halothane techniques using a more conventional anaesthetic machine. In fact there is some suggestion that the patient's symptomatic recovery is better when air has been used as the carrier gas, in spite of the fact that a rather higher concentration of halothane may have to be given to compensate for the absence of the complementary sedative and analgesic effects of the nitrous oxide.

It is not suggested, however, that the apparatus provides a foolproof method of anaesthesia for inexperienced anaesthetists. Halothane presents the same potential dangers, whichever way it is administered. Its high potency infers a smaller margin of safety from overdose than is the case with ether, and less reliance can be put upon the patient's spontaneous respiration maintaining adequate pulmonary ventilation owing to the respiratory depressant effect of the drug.

The only real virtue claimed for the apparatus is that, in circumstances when nitrous oxide and more elaborate apparatus are difficult to procure, it enables the anaesthetist to take advantage of the special features of halothane anaesthesia, without loss of precision and control, to the benefit of both surgeon and patient.
ACKNOWLEDGMENTS
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REFERENCES

APPAREILS TRANSPORTABLES POUR ANESTHESIE A L’HALOTHANE

SOMMAIRE
L’halothane, comme l’éther, peut être administré de façon précise et efficace avec un appareil assez simple qui emploie le principe de “tirer au-dessus” avec de l’air atmosphérique comme gaz porteur. On décrit un ensemble portatif, conçu sur ces principes pour anesthésie à l’halothane/air, fournissant à l’anesthésiste un appareil indépendant complet, prêt à l’emploi immédiat. Les caractéristiques essentielles de cet ensemble comprennent un vaporisateur à température compensée pour l’halothane — moyen d’augmenter avec précision et économie l’air aspiré d’oxygène — et un système de valves automatiques qui permet la respiration, à pression positive, tant spontanée qu’intermittente. On suggère que cet appareil aura peut-être un rôle utile dans des régions en voie de développement, avec les Services Médicaux des Forces Armées en service actif outre-mer et dans d’autres conditions lorsque les appareils plus compliqués et les fournitures d’oxyde nitreux ne sont pas facilement disponibles.

TRANSPORTABLER APPIAT FUR HALOTHAN NARKOSE

ZUSAMMENFASSUNG

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