HALOTHANE-AIR ANAESTHESIA USING THE "PULMOTEC" APPARATUS

PRELIMINARY REPORT

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DUE TO the extreme potency of halothane the usual range of clinical concentration is very low (0.5–2.5 per cent). This suggests that vaporization with air should be possible without materially compromising the oxygen supply to the tissues, since the gas displaced by the halothane would be mostly nitrogen. A glance at the oxygen-haemoglobin dissociation curve shows that minor variations in PO_2 at the right-hand side between 80–100 mm. Hg have only minor effects upon the percentage saturation of haemoglobin.

In the event of mass casualties from atomic warfare and so on, it is quite possible that in many areas the supply of compressed gases would fail. As far as anaesthesia is concerned, this has important implications when one realizes that without compressed gases an anaesthetic machine is as useless for anaesthesia and resuscitation as an automobile without gasoline. While the loss of gases would still leave open drop, local, regional, and intravenous techniques, when controlled or assisted ventilation is mandatory some means of inflating the lungs could be life saving.

The recent introduction of the thick-walled foam rubber bag and automatic non-rebreathing valve, in such examples as the Ruben Resuscitator from Denmark using the Ruben valve and the Pulmonator Resuscitator from the United States using the Lewis-Leigh valve, suggests a ready application to the problem. Either of these devices in conjunction with halothane in a Fluotec vaporizer should provide us with a simple portable draw-over type of anaesthetic machine, completely independent of compressed gases, having a controllable anaesthetic concentration and no explosion hazard.

DESCRIPTION OF APPARATUS

Figure 1 is a photograph of the assembled apparatus. It consists of the following:

1. A Pulmonator Resuscitator (Western Anaesthesia Equipment Co.), made up of a rubber bag inside which is a thick-walled foam plastic liner. The capacity of the bag is 5 litres (2 L. size is also available). At either end of the bag is a short length of hollow plastic tube which projects some distance into the interior. On the back end is a unidirectional flap valve moving air always in a forward direction. The Lewis-Leigh valve fits on the front end of the bag and is designed

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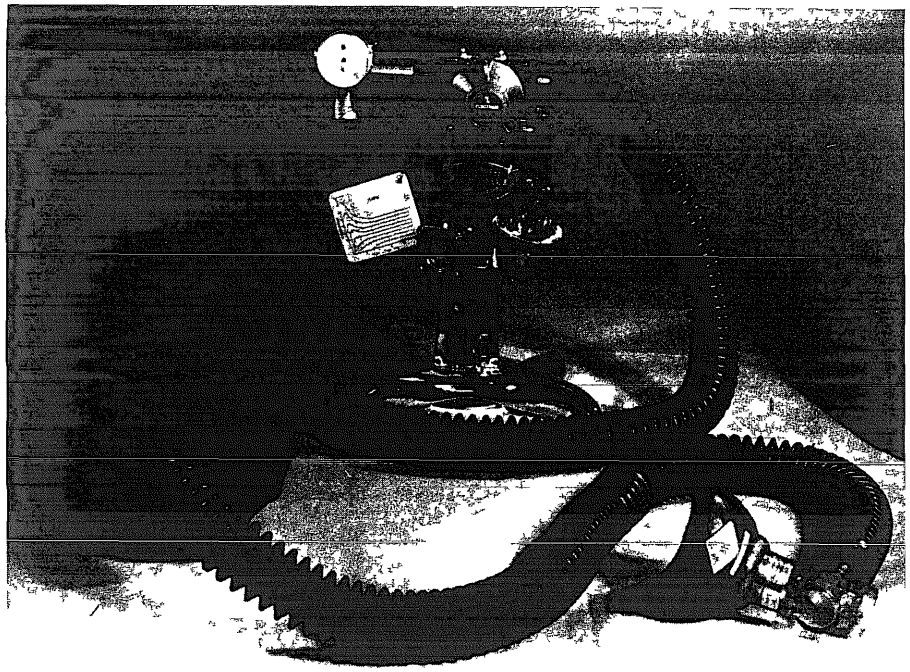

FIGURE 1

in such a way that compression of the bag forces a siliconized rubber flap to occlude the exhalation tube, the end of which is cut on an angle. Thus air can only move outwards through the mask. During exhalation, the rubber flap falls back against the inhalation opening and expired air can leave only through the exhalation tube. The author has modified the valve by adding an additional flap on the outside of the exhalation vent to ensure that with spontaneous breathing air can be drawn in only via the vaporizer. Both the M.I.E. and Heidbrink female adaptors will fit the valve, as well as a 15-mm. male endotracheal connector.

2. A Mk. II Fluotec halothane vaporizer on a stand with suction cup base.

3. Two lengths of standard anaesthetic hose. It is clear that the bag may be placed at any point behind the valve, and it was found convenient to have it remote from the face.

4. A Wright anemometer was added to the apparatus and placed at the air intake side to avoid moisture laden exhaled air and halothane vapour passing through it.

Selection of Cases

The series consists essentially of 102 consecutive list cases. Ages ranged from 18 months to 89 years. The types of operation performed, which were mostly of a major nature, are shown below.

Classification of 102 Cases

E.E.N.T.	20	Major Plastic	5
Major Abdominal	19	Varicose veins	5
Urology	13	Radical mastectomy	2
Major Orthopedics	8	Radical neck dissection	2
Gynaecology	6	Thoracotomy	1
Neurosurgery	6	Thyroidectomy	1
Dental	6	Cardiac catheterization	1
Breast Biopsy	6	Amputation of legs	1

Technique

Premedication was as follows. Adults received pentobarbital 1½ to 3 gr. two hours preoperatively; morphine ⅛ to ¼ gr., and atropine 1/150 to 1/50 gr. one hour preoperatively. Children and the aged were premedicated in accordance with weight and general condition.

Induction and Maintenance

The majority of cases received thiopentone intravenously in standard dosages. Where intubation was performed succinylcholine 20–60 mg. was used.

Blood pressure was measured in the usual way with a cuff on the upper arm, and was monitored very frequently along with pulse rate, tidal and minute volumes.

Early in the series it was clear that the most satisfactory technique was to hyperventilate patients with 2 to 3 per cent halothane following induction.

Gradually the concentration was reduced until after 10 to 20 minutes a maintenance setting of 0.5 to 1.5 per cent was quite satisfactory.

With light premedication higher maintenance concentrations were generally needed, and conversely with heavy sedation.

Where a lower setting than 2 per cent was used immediately following induction, patients frequently reacted to the surgery, requiring either additional thiopentone, meperidine, or a rapid increase in concentration.

In two cases, halothane-air was employed for induction but was slow and unsatisfactory. In children, however, halothane-air induction was often very rapid and in one case the child was easily intubated after two minutes of 2 per cent halothane. As with halothane generally, blood pressure always fell to a lower level, but the hypotension was never severe enough to require a vasopresser. Hypotension could be avoided by intravenous atropine 1/100 gr. during induction and remedied when required either by atropine or by lowering the concentration unless reaction to surgery was thereby provoked.

Usually, a fall in blood pressure to around 80 to 90 mm. Hg was well tolerated and produced a dry surgical field. Spontaneous ventilation could be readily overridden and controlled, and, in fact, it was very simple to wash out enough CO_2 to produce apnoea for a considerable period.

Abdominal relaxation was often adequate with hyperventilation and halothane, but when unsatisfactory was achieved by intermittent intravenous succinylcholine. In a few instances intermittent gallamine was used.

Minute volumes of 8 to 10 L. could be maintained with the greatest of ease and tidal volumes of up to 2,000 c.c. were readily produced by squeezing the pulmonator bag. Once a steady maintenance concentration setting was achieved, spontaneous ventilation was generally quite adequate as judged by tidal and minute volume readings in relation to age and weight. Blood colour was quite acceptable. Where ventilation was below the predicted normal value it was assisted manually.

It was noted that beyond the 2.5 per cent concentration setting on the Fluotec, resistance to flow increased appreciably. However, this presented no problem as at this setting, or greater, spontaneous ventilation required assistance anyway, and with controlled ventilation the only effect was a slowing in the rate of refilling of the bag. Since maintenance was generally at a much lower setting the fact was of little practical importance.

Blood Colour

Although estimation of arterial O_2 saturation by the visual method is far from quantitative, so long as ventilation was adequate in accordance with the Radford nomogram arterial blood appeared satisfactorily pink. Generally, patients were hyperventilated to be on the safe side. However, when ventilation was stopped or allowed to be deficient, cyanosis rapidly became obvious. With air vaporization it can probably be assumed that in the steady state if the blood appears pink the P_{CO_2} level is within the normal range. This is in contrast to hypoventilation with high oxygen percentage mixtures where high oxygen saturation and high P_{CO_2} levels can be present simultaneously.

Halothane Consumption

This was estimated by measuring the exact amount of halothane needed to bring the vaporizer liquid level back to its original mark after using the same setting for periods of one hour and over. Using controlled ventilation 8 to 10 L./min. the following consumptions were found: 1 per cent: 10–15 c.c./hr.; 1.5 per cent: 15–20 c.c./hr.; 2.0–2.5 per cent: 20–25 c.c./hr.

There were no untoward events in the series, and the incidence of postoperative nausea and vomiting was very low. Three patients complained of nausea and two of nausea and vomiting which could be attributed to the anaesthetic. There was one death in the series. This was a 75-year-old woman who was admitted moribund with severe toxaemia following a ruptured appendix. She died 24 hours following laparotomy, but it is unlikely that anaesthesia played any part in her death.

Special Cases

Two men with severe emphysema were anaesthetized for cystoscopy with this technique and were allowed to breathe spontaneously throughout with intermittent assistance. There was no tendency to apnoea as with high oxygen concentrations and both were awake and talking on completion of the surgery.

An 18-month-old child was anaesthetized for cardiac catheterization by this method and it proved most satisfactory, with no interference with blood gas studies. She had previously been investigated under local anaesthesia and arterial oxygen saturation was 93 per cent. An identical figure was obtained during halothane-air anaesthesia with spontaneous respiration.

Conclusion

The "Pulmotec" is a simple portable apparatus capable of delivering a very satisfactory anaesthetic without the need for compressed gases. Apart from any use it might possibly have in emergency situations, it has proved very satisfactory for anaesthesia in dental offices where portability and rapid nausea-free emergence is invaluable. Since vaporization takes place only during the inhalation phase, halothane consumption is quite moderate. An additional advantage is that the apparatus without the vaporizer is a very effective resuscitator. Since there is no rebreathing, soda-lime is unnecessary. The manufacturers of the Fluotec (Cyprane Ltd., England) have assured me that even at flow rates of 30 L. per min. through the vaporizer, concentrations still remain at the indicated setting. The apparatus can be further simplified by using the smaller vaporizers such as the Rowbotham or Goldman, though as accurate a calibration would not be possible as with the "Fluotec."

In a further study it is planned to follow arterial blood oxygen saturation levels during halothane-air anaesthesia.

Summary

A simple portable apparatus has been described for the administration of halothane with air vaporization.

The equipment consists of a Pulmonator Resuscitator, a Mk. II Fluotec vaporizer, and a Wright ventilometer. While designed mainly for possible military field use and national catastrophe, it will provide a very satisfactory non-explosive anaesthetic without the need for compressed gases.

Possible indications for its peacetime use in hospitals would be severe emphysema, to avoid apnoea from high oxygen concentrations, and cardiac catheterization where the use of N_2O interferes with blood gas analysis.

In the interests of economy or improved portability, simpler vaporizers can be successfully employed. The Pulmotec is also instantly available as a resuscitator where anaesthesia is not required.

Acknowledgment

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Résumé

Nous avons décrit, ci-contre, un appareil portatif pour l'administration de l'halothane vaporisé avec de l'air.

L'installation consiste en un pulmonateur resuscitateur, un vaporisateur Fluotec Mark II et un ventilomètre Wright. Bien que cet appareil soit construit particulièrement pour usage possible en campagne militaire et en cas de catastrophe nationale, il peut permettre l'administration très satisfaisante d'une anesthésie sans risque d'explosion et sans recourir à des gaz sous pression.

Les indications possibles de son usage en temps de paix dans nos hôpitaux seraient: les cas d'emphsème marqué, la crainte de produire l'apnée en employant de grandes concentrations d'oxygène dans l'atmosphère que le malade respire et, au cours des cathétérismes cardiaques, l'élimination du protoxide d'azote qui modifie les résultats des analyses de gaz dans le sang.

Des vaporisateurs plus simples peuvent être employés avec succès; il y en a de plus économiques et plus facilement portatifs. S'il n'est pas nécessaire d'administrer de l'anesthésie, le pulmotec est utilisable instantanément comme resuscitateur.