A SIMPLE HALOTHANE VAPORIZER

Measurement of Halothane and Oxygen Mixture by means of a Cyclopropane Flowmeter

BY

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The apparatus to be described represents an attempt to develop a simple, cheap halothane vaporizer which could be used without modification of existing anaesthetic equipment and which would allow accurate but economical use of halothane. An earlier version of this vaporizer has been described (Cole, 1959) and the present model has already been referred to (Cole, 1960). The aim of the present paper is to describe the vaporizer and to record experiences of performance after extensive use by the writer and by a number of other anaesthetists to whom vaporizers have been supplied.

The vaporizer (fig. 1) consists of a metal assembly into which is screwed a 100-ml bottle with a suitable washer intervening. The projecting side tube is the oxygen inlet. Oxygen enters here, passes through ducts drilled in the metal and then through a vertical tube 8.25 cm long to escape through a jet 1.5 mm in diameter 2 cm above the bottom of the bottle. A safety valve which is spring loaded to open at 5 lb./sq. in., is set in the metal cap and is connected with the oxygen duct so that if the pressure exceeds that figure only oxygen escapes. The oxygen and halothane mixture leaves the apparatus through a metal tube which terminates in a yoke block.

Before use the apparatus is filled with halothane to a level just below the inlet pipe (about 22 ml), screwed into the cyclopropane yoke, and connected to a supply of oxygen. It is now possible to pass a halothane and oxygen mixture through the cyclopropane flowmeter. The amounts of oxygen and halothane vapour flowing per minute for different readings of the flowmeter are shown in table I. The readings were made with the halothane maintained at a temperature of 18.3°C (65°F) as this was felt to be the most useful temperature for calibration.

In use the concentrated halothane vapour is metered by the cyclopropane flowmeter and is
added to oxygen and nitrous oxide passing from their own flowmeters to form an anaesthetic mixture. This is administered to the patient with a carbon dioxide absorption apparatus, except in small infants in whom non-rebreathing techniques are used.

An example might clarify the technique. Consider a robust man for an orthopaedic procedure on the lower limb. Anaesthesia is induced with thiopentone 500 mg which produces sufficient anaesthesia to allow the immediate application of a tourniquet. The inhalation anaesthetic is commenced when respiration returns, with flows of oxygen 1 l./min, nitrous oxide 2 l./min and the oxygen and halothane mixture at a cyclopropane flowmeter reading of 600 ml/min. When the rebreathing bag is half filled the rates of flow are reduced to oxygen 500 ml/min, nitrous oxide 800 ml/min* and the oxygen and halothane vapour to a reading of 500 ml/min. During the next 10 minutes the halothane mixture is gradually reduced to a flowmeter reading of 200 ml/min. When the operation has almost finished and suturing is commencing the nitrous oxide and the halothane vapour are both turned off, the oxygen is reduced to basal flow and the apparatus is wholly closed. This provides lightening anaesthesia until the completion of surgery. In making calculation it is best to think in terms of ml of pure halothane vapour flowing per minute for settings of the cyclopropane flowmeter. Changing this into percentages of the whole gas flow is then a matter of simple arithmetic.

It is, of course, possible to administer gases at different rates of flow or to close the apparatus and use only the basal rates of flow (after anaesthesia has been stabilized). The figures for maintenance of light stage 3 anaesthesia with different flows of gases are approximately as shown in table II.

It is interesting to note that, even when anaesthesia is stabilized and the system wholly closed so that no anaesthetic agent escapes, an amount

*The flow rate of nitrous oxide is measured using the carbon dioxide flowmeter. Since carbon dioxide and nitrous oxide have approximately the same molecular weight and viscosity the flowmeter reading for nitrous oxide is accepted as correct.

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**Table I**

*Calibration of vaporizer at 18.3°C.*

<table>
<thead>
<tr>
<th>Oxygen flowrate (ml/min)</th>
<th>Halothane vapour flow (ml/min)</th>
<th>Cyclopropane flowmeter reading (ml/min)</th>
<th>Per cent concentration of vapour by volume</th>
<th>Liquid halothane vaporized per hour (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>158.5</td>
<td>800 (estimate)</td>
<td>24.2</td>
<td>42</td>
</tr>
<tr>
<td>400</td>
<td>113</td>
<td>700</td>
<td>22.2</td>
<td>30</td>
</tr>
<tr>
<td>300</td>
<td>90.6</td>
<td>500</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>200</td>
<td>50</td>
<td>400</td>
<td>13.2</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>25</td>
<td>200</td>
<td>6.6</td>
<td></td>
</tr>
</tbody>
</table>

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**Table II**

*Rates of flow needed to maintain light stage 3 anaesthesia in adults.*

<table>
<thead>
<tr>
<th>Oxygen (ml/min)</th>
<th>Nitrous oxide (ml/min)</th>
<th>Oxygen-halothane mixture. Cyclo. flowmeter reading (ml/min)</th>
<th>Pure halothane vapour flow (ml/min)</th>
<th>Concentration of halothane (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>2,000</td>
<td>300</td>
<td>37</td>
<td>1.18</td>
</tr>
<tr>
<td>500</td>
<td>800</td>
<td>200</td>
<td>25</td>
<td>1.78</td>
</tr>
<tr>
<td>250</td>
<td>—</td>
<td>100-150</td>
<td>10-15</td>
<td>3-4</td>
</tr>
</tbody>
</table>
of 10 to 15 ml/min of pure halothane vapour must be given to maintain anaesthesia. It would appear, therefore, that halothane usage will not fall below this minimum amount which corresponds to about 4 ml of liquid halothane per hour.

**DISCUSSION**

Various points have been found by experience to be of importance in the operation of this vaporizer. Difficulty has been encountered in finding a suitable washer to ensure a gastight fit between the bottle and the metal assembly. Two washers appear to be necessary; a compressible one inserted first and a tough wear-resisting washer to make contact with the bottle. The best combination so far found is a synthetic rubber washer put in first and over this a polyethylene one. If excessively rigid washers are used there is a tendency to break bottles during the screwing-in process. This tendency can be further lessened by grinding the bottle to fit the metal assembly with valve grinding compound.

It has been found that during the induction phase the greater vaporization of halothane causes the temperature of the halothane in the bottle to fall by about 5°C. During maintenance of anaesthesia the halothane regains warmth and at the end of the operation is within 2°C of room temperature. On occasions the operating room temperature has risen during the anaesthetic administration. In such cases the halothane has been warmer at the end of the operation than at the beginning. Operating theatres in Australia are usually heated in winter and cooled in summer, so that the working temperature is usually between 18.3°C and 22°C. If the apparatus were used under different temperature conditions calibration would have to be repeated for other temperatures. As a result of these temperature measurements, together with experience of the apparatus in use it is believed that with low rates of flow there is no need to make corrections for temperature variations during use.

Although the safety valve is set for 5 lb./sq.in. the apparatus is usually used with a pressure of about 2 lb./sq.in., as the tendency for leakage at the washer is less at the lower pressure. However, pressures as low as 3/4 lb./sq.in. will operate the cyclopropane flowmeter. Variations in the concentration of halothane vapour arising from alterations in pressure must occur but do not appear to be important.

The small oxygen inlet (1.5 mm) projects the oxygen as a jet on to the surface of the liquid halothane so that variations in the level of the halothane do not greatly influence the concentration of the vapour. The earlier vaporizer, which had a 5-mm inlet, gave lower vapour concentrations and showed considerable variations in concentration relative to halothane level.

Because there are no moving parts and as the specifications are easily reproducible there is no detectable variation in performance of a vaporizer at different times or between different vaporizers. The vaporizer is easily made and probably costs less than any of the vaporizers intended specifically for halothane.

Because of the small rates of flow employed during the maintenance of anaesthesia, halothane and nitrous oxide usage are both small. The writer averages 3.75 ml of halothane per patient. There does not appear to be any damage to the apparatus from the passage through the cyclopropane flowmeter of a vapour different from the one for which it was intended.

When this vaporizer is considered in relation to the papers by Mapleson (1960), Galloon (1960), and Mushin and Galloon (1960), it will be seen that although it is designed to work with small rates of flow it is still an arrangement in which the vaporizer is outside the breathing circuit (V.O.C.) and behaves accordingly in the manner described in these papers. To some extent this vaporizer bridges the gap between the economy of the V.I.C. assembly and the controllability of the V.O.C.

**SUMMARY**

The conception developed by Morris (1952) of separate vaporization of liquid anaesthetics and subsequent addition of the vapour to the gaseous output of nitrous oxide and oxygen from the anaesthetic machine has been applied to halothane, using the cyclopropane flowmeter as a metering device. The apparatus is simple, cheap, and effects worthwhile economy in halothane and nitrous oxide.

**ACKNOWLEDGMENTS**

I wish to acknowledge the help of Imperial Chemical Industries Limited and their medical executive, Mr. Wolfe, who supplied the halothane (Fluothane) used.
in the development of this apparatus, I would like to thank Professor W. W. Mushin who has kindly tested this vaporizer. The photograph was taken by Mr. Cottier, chief photographer at Victoria Eye and Ear Hospital. The vaporizers were made by Ramsden and Chaplin Limited of Melbourne (Mr. Richards, engineer).

REFERENCES


BOOK REVIEW

Resuscitation of the Newborn Infant. Edited by Professor Harold Abramson. Published by Henry Kimpton, London. Pp. 274; illustrated. Price 7s. 6d.

This book deals with a subject that has frequently provoked argument and discussion among paediatricians, obstetricians and anaesthetists. It suggests that of these three, the anaesthetist is "most admirably suited to lead in the development of programmes of resuscitation", a view as yet not generally accepted in this country. There is indeed very little with which the anaesthetist would disagree. The chapters on "Resuscitation procedures in the delivery room" and "drug therapy" are written with clarity and common sense. It is particularly refreshing to see some of the commonly used resuscitative procedures critically evaluated and their limitations exposed. One can agree with many of the sections, in particular those dealing with intragastric oxygen, phrenic nerve stimulation, and the principle and practice of pulmonary ventilation. If, however, the reader restricts himself to those chapters relevant to his specialty he will have grasped only a facet of this large problem.

Since twenty-four specialists have contributed to this book, the problem is viewed from many aspects. "It encompasses the investigation, early recognition, and appraisal of all influences operating before conception, during pregnancy and around the birth of the baby, and immediately after birth which may possibly contribute to perinatal distress." The dominant theme is the avoidance of foetal anoxia. The first chapters deal with the size of this problem and the underlying basic physiological and pathological causes. Maternal factors and the management of the mother during labour, including the influence of anaesthesia, are considered. Further chapters deal with resuscitation, mechanical respirators, the examination of the newborn infant, and suggestions for the layout of the recovery nursery.

The concluding chapter indicates the lines along which research and development should continue.

In a book written by so many contributors some variation in quality and style of writing must be expected, but the editor has produced a volume which is, on the whole, readable and which contains a comprehensive bibliography.

There is no doubt that if all those interested in the resuscitation of the newborn infant were to co-operate as the authors of this book have done, neonatal mortality would be reduced. This book has rendered a great service to unborn children in re-emphasizing once again the necessity for co-operation between the obstetrician, anaesthetist, paediatrician and pathologist, all of whom have vital parts to play if the infant is to survive.

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