CLOSED CIRCUIT ANAESTHESIA BY INTERMITTENT INJECTIONS OF HALOTHANE

BY

BERNARD WOLFSON*

Department of Anaesthetics, Western Infirmary, Glasgow, Scotland

SUMMARY

Anaesthesia produced by intermittent injections of halothane into the oxygen inflow of a closed circuit has been described in a series of 136 cases. The advantages of accuracy, safety and economy have been discussed.

The Comptroller and Auditor-General in his survey of the Appropriation Accounts for 1960–61 scrutinized the use of "a general anaesthetic" introduced in 1954. In 1960–61, hospital purchases of this agent amounted to more than £500,000, and already in 1961–62 the rate of use has risen by 20 per cent (Lancet, 1962). This statement, which must refer to halothane, inevitably gives pause for thought. It can reasonably be accepted that halothane has established a place for itself in anaesthesia and a stage has been reached already when many anaesthetists would greatly dislike to do without it. Nevertheless the cost of the drug must cause concern and the use of closed-circuit anaesthesia in an effort to mitigate this disadvantage has become very popular.

The principles governing the use of halothane in a closed circuit have been enunciated by Mushin and Galloon (1960). When basal flows are used with the vaporizer inside the circuit inefficiency of the vaporizer is a desirable safeguard, and assisted or controlled respiration, if used at all, must be carried out with great caution. Although a very large series using this system has been described by Marrett (1959), the restriction on controlled respiration makes it unpopular with many anaesthetists. When the vaporizer is outside the circuit it must be efficient and accurate, and is therefore usually expensive. On occasion it may be dangerously liable to error and indeed a case of cardiac arrest has been reported by Baxter (1960) where a calibrated vaporizer had developed a fault which led to the delivery of concentrations far in excess of those indicated. It has been pointed out by Johnstone (1961) that reference solely to the concentration of halothane issuing from a vaporizer does not warrant conclusions as to the probable effect on the patient. Concentration plus flow rate must be considered in order that the anaesthetist may know the total quantity of halothane vapour made available to the patient. This quantity is known automatically when known volumes of halothane are vaporized completely in a closed circuit (1 ml of liquid halothane produces 226 ml of vapour at 20°C and 760 mm Hg atmospheric pressure). Intermittent injection of liquid halothane directly into the expiratory limb or the gas inlet of a circle rebreathing system has been described by Hampton and Flickinger (1961) and the use of a modified Goldman drip feed by Romagnoli, Cohen and Diamond (1960).

This paper describes the use of intermittent injections of halothane into a home-made vaporizer which can be used with either a circle or a to-and-fro type of closed system. The apparatus is shown in figure 1 and consists of two parallel brass chambers, one of which has a mount through which halothane is injected from a 5-ml syringe. This chamber contains a gauze swab which disperses the liquid and thus presents a large area for vaporization by the incoming gas. The second chamber merely acts as a by-pass so that the vaporizer may be cut out of the circuit at will.

The vaporizer is interposed between the gas outlet of the Boyle machine and the absorption circuit, either circle or to-and-fro. It is placed on the table of the machine or any other convenient surface as shown in figure 2.

* Present address: Royal Alexandra Infirmary, Paisley.
The performance of the vaporizer as shown by the time taken to vaporize 1 ml of halothane at 18°C at different flow rates is shown in figure 3. The percentage of halothane issuing from the vaporizer, although not that inhaled by the patient, is also shown.

METHODS
One hundred and thirty-six patients, ranging in age from 12 to 88 years, were anaesthetized for intraperitoneal, extraperitoneal and intrathoracic (but extrapulmonary) procedures. Premedication in the majority of cases consisted of papaveretum and hyoscine hydrobromide, morphine and atropine, or pethidine and atropine in accepted dosages depending on the age and condition of the patients. In addition, a few patients received a mixture of promethazine, pethidine and atropine. Anaesthesia was always induced with thiopentone in doses ranging from 150 to 500 mg. Intubation, when this was performed, was facilitated either by gallamine, when it was intended to control respiration, i.e. for all intraperitoneal and intrathoracic surgical procedures, or by suxamethonium when spontaneous respiration was planned. After intubation the circuit was filled with oxygen with the vaporizer cut out and the patient’s lungs were inflated a few times while the circuit was tested for leaks. The flow rate was then reduced to 300–1000 ml oxygen (usually 500 ml); the vaporizer, into which 1 ml of halothane had already been injected, was brought into the circuit and the patient gently inflated. In most instances, by the time the effect of the suxamethonium had worn off, the patient tolerated the endotracheal tube. Further injections, however, were almost always required to avoid movement when the skin incision was made and 1 or 2 additional ml were often necessary within the first 10 or 15 minutes. Repeat injections, based upon responses to surgical stimuli and changes in blood pressure, pulse and respiratory rate, were given throughout the operation. When requirements had been misjudged it was sometimes necessary to re-establish control by increasing the flow rate to 1–3 l./min concurrently with the injection of a further 1 ml of halothane. The swift vaporization of this ml was usually sufficient to subdue the patient very quickly and thereafter a return was made to basal flows. With growing experience of this technique, these adjustments were less frequently necessary.

In those patients who were not intubated (39), a tight fitting facepiece was applied after induction with thiopentone and the same routine carried
CLOSED CIRCUIT ANAESTHESIA BY INTERMITTENT INJECTIONS

![Graphic representation of vaporization of 1 ml halothane at different flow rates.](image)

Fig. 3

out as described above. An oropharyngeal airway could usually be introduced after 1 or 2 ml of halothane had been injected. In some cases, to facilitate this introduction at an earlier stage, a small dose of gallamine was given with the induction dose of thiopentone. This method was used especially when a degree of muscular relaxation was required, as, for example, during herniorrhaphy. In general no attempt was made to produce relaxation with halothane alone although occasionally an injection of 1 ml, made immediately before closure of the peritoneum, was used as a satisfactory substitute for a further dose of relaxant.

RESULTS

Anaesthetic records are shown for one case in which controlled respiration was used (fig. 4) and one case in which respiration was spontaneous (fig. 5). These charts show readings only after the halothane has been started, that is after intubation. The tachycardia shown in figure 4 followed on the injection of gallamine 120 mg. In general, tachycardia due to gallamine was more common than bradycardia due to halothane when the two agents were used together, although tachycardia of the degree seen in this patient was unusual.

In a number of cases where spontaneous respiration was deemed inadequate, assistance to respiration was employed. It was usually possible, however, to avoid apnoea. Hypotension was never deliberately sought and although observed in a number of cases was always of moderate degree and never a worrying factor.

Table I shows the average consumption of halothane in all cases and a breakdown of these cases into those lasting more and those lasting less than 1 hour.

Tables II and III show the results of similar calculations taking cases with controlled respiration and with spontaneous respiration separately.
Table IV shows the average consumption for the first full hour and the second full hour of anaesthesia. These figures are compared for controlled and spontaneous respiration.

From these it can be seen that the rate of halothane consumption is greater in shorter operations. The demand, as might be expected, falls progressively and this fall is more marked when respiration is controlled. The quantities of gallamine required appeared to be less than would have been needed if nitrous oxide/oxygen anaesthesia had been used. This is in keeping with findings by Foldes, Sokoll and Wolfson (1961).

**DISCUSSION**

Using this method the exact amount of halothane vaporized is known at all times, thus obviating the need for a calibrated vaporizer. As only small increments are used, overdosage is unlikely and accidental overdosage virtually impossible. The vaporization is independent of the patient’s respiratory minute volume, making controlled respiration perfectly safe.

Hampton and Flickinger (1961) reported some difficulty in providing sufficient analgesia for the skin incision within the first 20 minutes. This was seen in only a few of the earlier cases in the present series in which, however, the average premedication was probably more potent and the average induction dose of thiopentone larger. In agreement with Hampton and Flickinger were the findings regarding recovery time. Although recovery time was not unreasonable it was not as short as one has come to expect with halothane used with an open circuit. If there was any reason to wish a very swift recovery the patient could be “washed

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**TABLE I**

*Average quantities of halothane used in all cases.*

<table>
<thead>
<tr>
<th>Number of cases</th>
<th>Average duration</th>
<th>Average quantity of halothane used</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cases</td>
<td>1 hr. 1 min.</td>
<td>6.1 ml/hr. (0.10 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting less than 1 hour</td>
<td>32 min.</td>
<td>7.8 ml/hr. (0.13 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting more than 1 hour</td>
<td>1 hr. 29 min.</td>
<td>5.5 ml/hr. (0.09 ml/min.)</td>
</tr>
</tbody>
</table>

**TABLE II**

*Average quantities of halothane used in cases with controlled respiration.*

<table>
<thead>
<tr>
<th>Number of cases</th>
<th>Average duration</th>
<th>Average quantity of halothane used</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cases</td>
<td>1 hr. 10 min.</td>
<td>5.2 ml/hr. (0.09 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting less than 1 hour</td>
<td>30 min.</td>
<td>7.8 ml/hr. (0.13 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting more than 1 hour</td>
<td>1 hr. 31 min.</td>
<td>4.7 ml/hr. (0.08 ml/min.)</td>
</tr>
</tbody>
</table>
TABLE III

Average quantities of halothane used in cases with spontaneous respiration.

<table>
<thead>
<tr>
<th></th>
<th>Number of cases</th>
<th>Average duration</th>
<th>Average quantity of halothane used</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cases</td>
<td>91</td>
<td>57 min.</td>
<td>6.5 ml/hr. (0.11 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting less than 1 hour</td>
<td>51</td>
<td>33 min.</td>
<td>7.8 ml/hr. (0.13 ml/min.)</td>
</tr>
<tr>
<td>Cases lasting more than 1 hour</td>
<td>40</td>
<td>1 hr. 28 min.</td>
<td>6.1 ml/hr. (0.10 ml/min.)</td>
</tr>
</tbody>
</table>

TABLE IV

Average quantities of halothane used in first and second full hour of anaesthesia.

<table>
<thead>
<tr>
<th></th>
<th>Controlled respiration</th>
<th>Spontaneous respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases having 1 full hour of anaesthesia</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Average quantity of halothane used in 1st hour.</td>
<td>5.6 ml</td>
<td>7.2 ml</td>
</tr>
<tr>
<td>Number of cases having 2 full hours of anaesthesia</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Average quantity of halothane used in 2nd hour</td>
<td>3.3 ml</td>
<td>4.3 ml</td>
</tr>
</tbody>
</table>

I wish to thank Mr. A. McDonald, instrument maker at the Western Infirmary, who constructed the vaporizer, and Mr. J. Cockton of Imperial Chemical Industries Ltd. who performed the gas analyses and produced the graphs seen in figure 1.

ACKNOWLEDGMENTS

I also wish to thank Dr. H. H. Pinkerton of the Department of Anaesthetics, Western Infirmary, for his help and encouragement in this project, and Mr. Gabriel Donald of the Department of Medical Illustration for his assistance in the production of the figures.

REFERENCES


SOMMAIRE

L'anesthésie produite par l'injection intermittente d'halothane dans l'embouchure d'oxygène en circuit fermé est décrite dans une série de 136 cas. Les avantages qui en résultent dans la précision, la sécurité et l'économie sont discutés.

ZUSAMMENFASSUNG