CYCLOPROPANE IN NON-EXPLOSIVE MIXTURE FOR OUT-PATIENT ANAESTHESIA

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The commonest anaesthetic for minor operations in this country is nitrous oxide. Inexpert administration often results in hypoxia, the dangers of which are well recognized.

In 1939 Courville described the serious neurological sequelae of hypoxia which sometimes follow nitrous oxide anaesthesia. His observations have been amply confirmed; in many papers, of which only a selection are listed (Murphy, 1940; Chase, 1941; Batten, 1942; Fletcher, 1945; Burdick, Lisa, and Elias, 1949; Bourne, 1951, 1952, 1957; Courville, 1955), nitrous oxide is either questioned as a suitable anaesthetic for minor surgery or even roundly condemned altogether, because of the difficulty of combining adequate anaesthesia with adequate oxygenation. Even special techniques, like those of Klock (1951, 1955) and of Tom (1956), which obviate any hypoxia because the operation is performed in a state bordering on consciousness called amnalgnesia, are not claimed to be successful in every patient and for every minor operation.

The fundamental disadvantage of nitrous oxide is its low anaesthetic potency; any attempt to deepen anaesthesia inevitably introduces hypoxia. In the case of major surgery the weak anaesthetic properties of nitrous oxide are supplemented with more potent drugs like ether, trichloroethylene, pethidine, or thiopentone, to say nothing of the relaxants. This cannot be done for out-patients except in the most minor degree because of the delay in recovery as well as of other side-effects which follow the use of these supplements.

Cyclopropane, however, is an anaesthetic which has desirable qualities in this connexion, since its potency allows full oxygenation, while the speed of induction and recovery is attractive for ambulant patients.

Pinson (1944) reported its use as a dental anaesthetic in 500 children. Following this, cyclopropane received a wide trial as an anaesthetic for out-patient and minor surgery (Pinson, 1945; Marston, 1945; Gillies, 1945; Bourne, 1952, 1954; Hingson, 1954).

An important drawback to cyclopropane is its flammability and the risk of explosion. This did not appear to be a deterrent to its use until Newton-Andrews (1954) observed that sparks were easily and indeed frequently produced when, in the course of a dental extraction, the forceps slipped on the enamel of a tooth. These sparks easily ignite mixtures of certain proportions of cyclopropane and oxygen (Bourne and Morton, 1955). Cyclopropane cannot therefore be accepted for dental anaesthesia unless it is administered in a non-explosive mixture. Such a mixture may be made by the addition of a suitable diluent gas such as helium or nitrogen (Macintosh, Mushin, and Epstein, 1958). Both are efficient, though on balance helium has some advantages. Electric sparks pass less easily through this gas, and

breathing the mixture is made more easy, helping to compensate for what is necessarily a slightly lowered oxygen concentration in the mixture. A practical method of using cyclopropane in non-explosive mixture with oxygen and helium was described by Jones and Thomas (1941).

Hingson (1954) had developed and described a simple portable inhaler* which used midget-size cylinders (similar to the "Sparklet" bulbs used for making soda-water at home) of various gases, including cyclopropane already mixed with nitrogen. Later, developing the work of Jones, Kennedy, and Thomas (1940), of the United States Bureau of Mines, he selected a mixture, for clinical use, of oxygen 30%, cyclopropane 40%, and helium 30%, which is non-explosive.

A similar apparatus has been developed in this country by Bourne, but instead of helium the more easily available nitrogen is used as diluent (Hewer and Lee, 1957).

Our own interest was aroused by Dr. Hingson, who kindly provided us with one of his inhalers and a supply of midget cylinders. Although Hingson's apparatus is readily available in the United States, neither his nor Bourne's is on sale in this country. As a result of our experiences with Hingson's apparatus we feel that the method is a real contribution towards more efficient and perhaps safer short anaesthetics for dental and minor surgery, in that it eliminates the very real dangers of hypoxia during the administration of nitrous oxide, without introducing the explosion hazard usually associated with the use of cyclopropane. This paper is presented in the hope that an apparatus of this sort will become available in Britain.

The Apparatus

The apparatus (Fig. 1) consists of a face-mask, a small soda-lime canister, two midget gas cylinders—one of oxygen/helium mixture and the other of cyclopropane/helium mixture—and a reservoir bag. The face-mask (1) is separated from the rest of the apparatus by a spring valve (2), which prevents the escape of gases from the bag before the apparatus is applied to the patient. Slight pressure of the mask on the patient's face opens this valve and allows inhalation from the bag. The valve can be fixed in the open position by engaging the spring clip (3) in a slot around the main casting. The soda-lime canister (4) is transparent and holds about 60 g. of soda lime. The reservoir bag (5) holds 6 litres. An expiratory valve is provided on the face-mask. Two aluminium covers (6, 6) between the reservoir bag and the soda-lime canister hold the midget gas cylinders at right angles to the main casting. When these covers are unscrewed the necks of the gas cylinders

FIG. 1.—Diagram of apparatus. For explanation see text.

*Known as the Western Reserve portable anaesthesia machine made by Z. and W. Inc., Wickliffe, Ohio, U.S.A.

can be pushed into rubber collars on the main body. Tightening up the cover forces the cylinder on to a metal pin which pierces the seal in its neck.

The cylinder contents flow through a hole in the piercing pin, past a non-return valve, into the reservoir bag, the mechanism being similar to that of the Sparklet soda-water siphon. Although an oxygen/helium cylinder can be pierced on either side of the apparatus, a cyclopropane/helium cylinder can be pierced only on the side which is distinctively coloured for cyclopropane. It is therefore impossible to use two cyclopropane/helium cylinders instead of one cyclopropane/helium and one oxygen/helium.

FIG. 2.—Apparatus in use.

If it is anticipated that anaesthesia will have to be prolonged, fresh cylinders are placed in the containers ready for piercing later.

The contents of one oxygen/helium cylinder mixed with that of one cyclopropane/helium cylinder produces 5,500 ml. of non-explosive mixture, containing 2,200 ml. of cyclopropane (40%), 1,650 ml. of oxygen (30%), and 1,650 ml. of helium (30%).

In use, the reservoir bag is first filled, as described, with the contents of one of each kind of cylinder. Hingson recommends that the oxygen/helium cylinder be emptied into the reservoir bag first, so that cyclopropane without oxygen cannot be inadvertently administered. The mask is now applied to the patient's face (Fig. 2) and the gas-retaining valve is locked open by the spring clip.

Clinical Experience

We first used this apparatus ourselves in the out-patient, dental, and casualty departments, and then placed it in the hands of some of our colleagues. We also invited an experienced general-practitioner anaesthetist (Dr. A. D. Griffith, of Barry) to use it and give us his comments. Altogether over 100 patients have been anaesthetized, the number being limited by the supply of the midget gas cylinders. We tried to avoid selection, but found that we inevitably turned to this method whenever we came across a patient in whom any anoxia was particularly undesirable or in whom, because of a previous turbulent experience, nitrous oxide was not considered a good choice.

Induction and Maintenance of Anaesthesia

Consciousness was lost within 15 to 30 seconds of commencing the administration. There were no complaints afterwards of difficulty in breathing during the induction. In no case was there objection to the immediate close

fitting of the mask to the face at the beginning of the administration. In from 45 to 90 seconds surgical anaesthesia was judged to be established. The signs were regular breathing, relaxation of the limbs and jaw, disappearance of the lid reflex, and, in dental cases, of any response to a mouth pack. In a few cases transient coughing occurred after consciousness had been lost but before surgical anaesthesia was established. The coughing was not marked, did not last for more than two or three respirations, and did not interrupt the administration.

In two cases struggling occurred during induction. One patient was a highly apprehensive woman who could not speak English, the other a mentally defective youth. In both the struggling soon subsided. Transient breath-holding occurred during induction in some cases. No treatment other than waiting for resumption of breathing was required. In no case did respiratory activity give cause for concern; apnoea did not occur.

In dental and other cases where the operation was in the region of the head, inhalation was continued for a time after anaesthesia was established. In general it was found that a period of two to three minutes' inhalation provided at least one minute of perfect operating time after the mask was removed. This period could be considerably extended by the nasal administration of nitrous oxide and oxygen. In these cases a suitable mouth pack was inserted and a clear airway maintained by the anaesthetist holding up the jaw and steadying the patient's head while the extractions were completed. Bleeding and salivation were sometimes a little freer than is usually seen with nitrous oxide. For this reason it is useful to have a sucker available. In other cases the inhalation was continued during the operation. Surgical anaesthesia was thus maintained for up to seven minutes. No cyanosis due to exhaustion of the charge of oxygen was noted during this length of time, except in one case when cyanosis developed after five minutes and it was found that the whole of the charge of oxygen had not been released into the reservoir bag.

The small soda-lime canister was clearly performing a useful function, since the "durasorb" brand of soda lime which we used began to change colour when inhalation was prolonged more than two to three minutes. To obtain further information on this point, we consulted our colleague, Dr. W. W. Mapleson, Ph.D., physicist to this department. Employing the laboratory technique of Bracken and Sanderson (1955), he found that with the canister filled with either "calona" or "durasorb" brand of soda-lime the concentration of carbon dioxide in the bag rose to about 1% by the end of the first two minutes and to 1½% by the end of five minutes. The value of the soda-lime canister was further demonstrated by experiments with volunteers in which the soda-lime canister was omitted. In these circumstances the carbon dioxide rose to 7% by the end of two minutes and 8% by three minutes (Fig. 3).

FIG. 3.—Percentage of carbon dioxide inhaled, with and without use of soda-lime.

Relaxation of the jaw was good enough to obviate the need for a mouth prop or gag in dental cases. When edentulous patients were anaesthetized lying down, a pharyngeal airway was nearly always necessary. None of the cases received any premedication.

Recovery

Recovery of consciousness occurred in most cases in one to one and a half minutes after discontinuing the admini-

stration. In the dental cases the surgeon was able to complete the operation before the patient recovered consciousness. After recovery of consciousness and of reflexes, some drowsiness and giddiness often persisted for up to 10 minutes, and most patients required assistance in walking away from the dental chair. Nearly 10% of the cases vomited in the immediate post-anaesthetic period. None vomited during anaesthesia. The vomiting was very slight, being in most cases one single retch. The frequency was higher than is our experience with nitrous oxide and oxygen.

Conclusion

The Hingson inhaler is practical and efficient for short general anaesthesia for minor procedures. The method eliminates hypoxia due to deficiency of oxygen in the inhaled mixture. The method is effective and satisfactory for operations which can be completed within, say, five minutes. It seems to be of special value in two types of patients: firstly, for anyone in whom an episode of hypoxia is particularly dangerous, and, secondly, for robust and "resistant" patients in whom difficulty with nitrous oxide can be anticipated. The chief disadvantages of the method seem to be the slightly higher incidence of vomiting than with nitrous oxide and oxygen even when the latter is supplemented with trichloroethylene and the slightly longer time required for the patient to recover enough to be allowed to walk unaided.

Two points remain for emphatic reconfirmation: (1) That the mixture in the bag is in no circumstance flammable or explosive. For this we have the authority of Dr. Hingson and his colleagues working in consultation with the U.S. Bureau of Mines. (2) That cyclopropane administered in this fashion will carry no higher morbidity or mortality than nitrous oxide. Hingson (1958, personal communication) has already anaesthetized over 5,000 patients, while Bourne's (1958, personal communication) experience runs to 3,000.

It must be emphasized that the certainty of non-explosibility of the mixture lies in the use of the special cylinders supplied. We strongly discourage any attempt to make a non-flammable mixture of cyclopropane for routine clinical use by drawing it from a cylinder of pure gas.

Summary

Nitrous oxide may be a dangerous anaesthetic if attempts to deepen anaesthesia are accompanied by hypoxia. Cyclopropane is free from this danger because its potency allows higher proportions of oxygen to be used. The Hingson apparatus (the Western Reserve portable anaesthesia machine), which permits cyclopropane from special midget cylinders to be administered in non-explosive mixture with helium and oxygen, is described. The clinical results of this method in 100 cases were so good as to engender the hope that an apparatus of this sort will be more widely available for trial in this country.

We thank Dr. R. A. Hingson, professor of anaesthesiology, Western Reserve University, Cleveland, Ohio, for the loan of his apparatus and a liberal supply of midget cylinders; Dr. W. W. Mapleson, Ph.D., for his investigation of the performance of the soda-lime canister; Mr. R. J. Marshall, A.I.B.P., F.R.P.S., for the photograph; Mr. E. K. Hillard, L.I.B.S.T., for the drawings; Dr. A. D. Griffith, of Barry, for his clinical help; and our colleagues and various out-patient sisters for their co-operation.

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STREPTOMYCIN DERMATITIS IN NURSES

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Sensitivity to streptomycin is very common. Since the first account by Heilman *et al.* (1954) a variety of dermatoses have been reported in patients treated with this antibiotic. The list includes pruritus, erythema, eczema, photosensitivity, urticaria, exfoliative dermatitis, and purpura. Occasionally the mucous membranes are affected, and cheilitis, stomatitis, and ulceration of the tongue have been described. Strauss and Warring (1947) reported an outbreak of dermatitis in nurses handling streptomycin, 4 out of 12 developing a rash on the hands and eyelids. Further reports (Rauchwerger *et al.*, 1948; Stringfellow, 1948; Wood, 1956) confirmed the fact that nurses giving streptomycin injections were liable to develop sensitivity to the drug.

Present Investigation

Over a period of eight years 14 cases of streptomycin dermatitis were seen among the nursing staff of one London hospital, two more were found during two years' observation at another London hospital, and two were referred from elsewhere. One subject was a male nurse; the remainder were females.

Clinical Features.—The sites most affected (Table I) were the sides and backs of the fingers, the backs of the hands, the forearms, the elbow flexures, and the face, par-

TABLE I.—*Sites Affected*

Case No.	Age at Onset	Hands	Arms	Eyelids	Cheeks	Neck	Legs
1	25	×	×		×	×	×
2	19			×			
3	19	×		×			
4	18		×	×		×	
5	24	×	×	×			
6	18	×	×		×		
7	18	×	×	×		×	
8	24	×	×				
9	19	×	×	×		×	×
10	21	×	×				
11	19	×					
12	36	×		×	×		
13	53	×	×	×			
14	46	×	×	×		×	
15	20	×					
16	21	×					
17	18	×					
18	27	×					

ticularly the eyelids (Fig. 1). Of the cases under investigation three had been so severely affected that they were obliged to give up nursing. One of these, however (Case 5), was able to resume after a course of desensitization. Details of her history are given below. Another was