NON-REBREATHING TECHNIQUES
Simple Adaptation of Standard British Apparatus

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INTRODUCTION
There are two standard types of non-rebreathing circuit for nitrous oxide-oxygen anaesthesia.

The first has been available for many years and is obtained with an intermittent flow type of apparatus (McKesson, Walton), a little positive pressure being used to give a continuous flow of gases. A uni-directional gravity check valve incorporated in the apparatus prevents rebreathing unless a reservoir bag is cut into the circuit. Artificial respiration cannot be used without changing to a semi-closed circuit.

The second is a more recent introduction and consists of a standard semi-closed circuit with the addition of a special non-rebreathing valve which is a uni-directional valve adjacent to or incorporated into the expiratory valve close to the face-piece. Artificial respiration by bag-pressure can be used.

Non-rebreathing also occurs in an Oxford Vaporizer where a uni-directional rubber flap valve lies close to the expiratory valve; and when inspiratory-expiratory valves are used for intermittent positive pressure artificial respiration.

Non-rebreathing technique in paediatric anaesthesia with specially designed non-rebreathing valves has been fully reported in the U.S.A. by Leigh and Kester (1948), Slater and Stephen (1951, 1952), Adriani and Griggs (1953), Griggs, Adriani and Benson (1953), Smith (1953) and others. Its value in paediatric anaesthesia is established in the United States, owing to the small respiratory volumes in infants, and requires no further comment.

There has been no British report.

A simple means of converting standard British apparatus to non-rebreathing technique follows.

ADVANTAGES OF NON-REBREATHING TECHNIQUES
In non-rebreathing technique the patient inhales only fresh gases from the machine; all exhaled gases pass directly out of the expiratory valve. The only rebreathing possible is from deadspace in the apparatus. Most of this is under the face-mask and is unavoidable, unless the gases are administered through an endotracheal tube, when the total deadspace may be less than physiological.

There are therefore these possible advantages over a semi-closed technique:

(1) “Expired” gases are not inhaled.
(2) The inhaled mixture is identical to that being delivered from the flowmeters, there being no nitrogen, water-vapour,
nor carbon dioxide to alter the concentrations.

(3) Respiration and anaesthesia are not complicated by an artificially high concentration of carbon dioxide in the inhaled mixture.

(4) The concentration of nitrous oxide and oxygen in the inhaled mixture can be more rapidly changed; this gives more precise control over oxygenation and depth of anaesthesia.

(5) Saturation with nitrous oxide and elimination of nitrogen are more rapidly achieved.

(6) A continuous record of the patient’s minute respiratory volume is obtainable for charting (see below). This is of particular value in teaching and clinical investigation, and serves as a simple check on the adequacy of a patient’s breathing before return to the ward, if relaxants or analgesics have been used.

British anaesthetists interested in using non-rebreathing technique with existing standard apparatus may do so as follows.

ADAPTATION OF CIRCLE ABSORBER TO NON-REBREATHEING CIRCUIT

To obtain a non-rebreathing circuit using a standard continuous flow apparatus such as Boyle’s, with a standard circle absorber (e.g. Coxeter-Mushin, Boyle Mk II), carry out one of the two following manoeuvres, which take only a few moments.

Method I. The simpler and quicker.

Use a circle absorber as a semi-closed circuit, with soda-lime turned off, expiratory valve at face-piece open, and a flow of about 8 l./min fresh gases; now place a clamp, such as a sponge forceps, on the expiratory hosing near the face-piece.*

On the Marrett apparatus simply remove expiratory hosing from port, insert stopper, and reconnect.

Method II. Has the advantage that only a single length of hosing is in use.

(1) Remove both lengths of hosing, with connections, from the absorber and place aside, as they are not used.

(2) Block the expiratory port with one of the following†: a cork, a rubber bung from a standard saline bottle, an endotracheal adaptor with a clamp across the rubber portion.

(3) Take a complete semi-closed (Magill) attachment and plug into inspiratory port.

(4) Turn bag control to “shut”.

(5) Open expiratory valve at face-piece.

(6) Run in about 8 l./min fresh gases.

By either method inspiration is entirely from the reservoir bag,‡ which contains only fresh gases; expiration is entirely through the expiratory valve. The unidirectional valve at the inspiratory port acts as a gravity check valve.

There should be sufficient tension on the expiratory valve to allow the reservoir bag to fill, if the outlet is occluded.

* On the Coxeter-Mushin absorber (and others) it is also advisable to empty the ether chamber, and turn the ether control full on. This diverts the fresh gases into the reservoir bag which otherwise pass along the inspiratory hosing during the pause between expiration and inspiration. This manoeuvre is essential if an M.R.V. reading is required.

† If this is not done the apparatus behaves as a “draw-over” circuit for ether (or Trilene) placed in the ether chamber, to which N₂O, O₂, CO₂ may be added. When a high flow of gases is used a non-rebreathing circuit is obtained, but if the patient takes a sharp inspiration air enters the circuit through the open expiratory port.

‡ “Reservoir bag” refers to bag in absorption circuit.
A change to a semi-closed circuit is instantly made by turning the bag control of the Magill attachment to "open" in method II; or, obviously, by removing the clamp in method I.

It is possible to carry out artificial respiration by bag pressure, but a valve which can be completely closed digitally during the inspiratory phase is required, e.g. Salt valve, and method II used.

A supply of fresh gases equal to or exceeding the patient's minute-respiratory-volume must be used.

CONTINUOUS RECORD OF MINUTE-RESPIRATORY-VOLUME (M.R.V.)

If the fresh gas-flow exceeds the patient's M.R.V. the reservoir bag will fill (provided there is some tension on the expiratory valve); if the flow is less than the patient's M.R.V. the bag will empty. If the flow is adjusted so that the bag neither tends to fill nor empty, then the sum of the readings on the flowmeters gives the patient's M.R.V.

This method of observing the M.R.V. is very simple, but no tracing is obtained. There are one or two small practical difficulties.

If the M.R.V. changes suddenly, a little time is taken adjusting the flowmeters and the relative concentrations of N₂O and O₂ are temporarily altered, with a possible change in the plane of anaesthesia; the patient's M.R.V. may sometimes exceed the maximum recordable gas-flow of N₂O and O₂, usually 15 l./min, necessitating the use of the by-passes or a change to semi-closed circuit. For the most part, however, a reading of the M.R.V. can be obtained once every minute for charting.

The use of this circuit at the end of an operation gives a simple check on the adequacy of a patient's breathing when relaxants (tubocurarine, etc.) or analgesics (pethidine, etc.) have been used, and will indicate whether neostigmine or nalorphine should be administered. If an adult's M.R.V. exceeds 7 l. it may be assumed that his breathing is adequate. No CO₂ should be used while the check is being made.

DISCUSSION

The main clinical advantage of a non-rebreathing circuit over a semi-closed circuit lies in the absence of an artificially high concentration of CO₂ in the inhaled mixture, but this is too wide a subject to be discussed here.

During light surgical anaesthesia respiration is less regular than in a semi-closed circuit, as pointed out by Clement (1945) who recommends partial rebreathing. For example, operative stimuli may cause hyperpnoea, which may be followed by apnoea (acapnia). This can be troublesome, and does not occur with a semi-closed circuit.

For a given gas-mixture the plane of anaesthesia tends to be lighter than with a semi-closed circuit, owing to the absence of the slight, but definite, narcotic action of CO₂ normally present in the inhaled mixture in the latter.

The technique is valuable for teaching purposes, or when drugs acting on the respiratory system are being investigated. For example, the following can be clearly demonstrated to students as the visual impression is more obvious, and recordable figures are obtainable; the respiratory depressant action of thiopentone, usually preceded by a short stimulation; the depressant action of pethidine and its
prevention or reversal by nalorphine; the depressant action of quite low (5 per cent to 10 per cent) concentrations of cyclopropane with nitrous oxide and oxygen; the stimulant action of low concentrations of CO₂, and so on.

SUMMARY

The two conventional types of non-rebreathing circuit are described. The possible advantages of non-rebreathing techniques are stated. Two simple ways of converting standard British apparatus to a non-rebreathing circuit are described.

A continuous record of the patient’s minute-respiratory-volume is obtainable for charting; it is valuable for teaching purposes, and clinical investigations; it is a simple check on the adequacy of a patient’s breathing at the end of an operation.

REFERENCES