DRAW-OVER ANAESTHESIA PART 1 - THEORY

Mr G Kamm, Anaesthetist, Muchami Hospital, Tanzania and Dr IH Wilson, Consultant Anaesthetist.

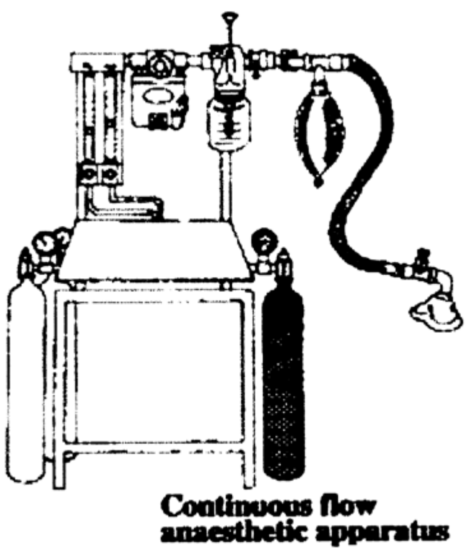
Introduction

In many parts of the world a regular supply of compressed anaesthetic gases cannot be maintained. Shortages of nitrous oxide are common and in some places oxygen is also unavailable. Anaesthetists working in such environments, whether in a developing country or in a disaster situation, may still be faced with patients requiring surgery necessitating techniques of anaesthesia not dependent on a supply of compressed gases. Suitable techniques include drawover anaesthesia, local anaesthesia and ketamine anaesthesia. This article considers the theory of drawover anaesthesia. Future editions of Update will contain articles covering the use of drawover systems for both adults and children, and care of the apparatus.

How does drawover anaesthesia differ from anaesthesia given with a Boyles machine?

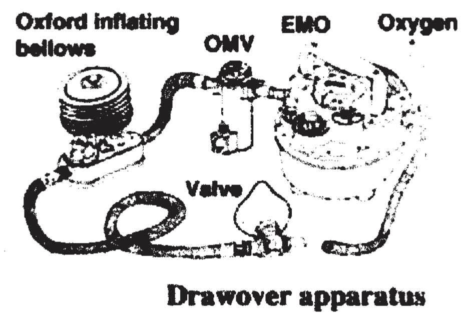
During anaesthesia using a Boyles machine (figure 1), compressed gases (oxygen and nitrous oxide or air) pass from cylinders mounted on the machine to rotameters, (a type of flow meter for gases), and then through the vaporizer where a volatile agent such as halothane is added to the gas mixture. The resulting mixture is delivered to the patient via an anaesthetic circuit, such as the Magill system. This type of anaesthesia system, known as "a continuous flow apparatus", is dependent on a supply of compressed gases. If these run out during an operation, so does the anaesthetic!

Figure 1



A drawover system (figure 2) is designed to provide anaesthesia without requiring a supply of compressed gases. Atmospheric air is used as the main carrier gas and is drawn by the patient's inspiratory effort through the vaporizer, where the volatile agent, normally ether or halothane, is added. The mixture is then inhaled by the patient via a non-rebreathing valve. The components of a drawover circuit are illustrated in figure 2.

Figure 2



Features of drawover apparatus:

1. Robust, compact and portable
2. Low purchase price and running costs
3. Straightforward maintenance
4. Not dependent on compressed gases

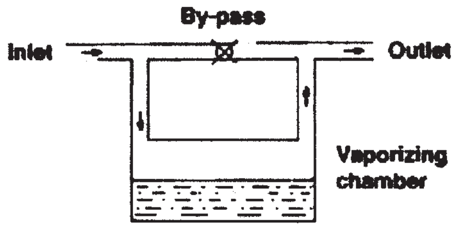
Function of the components of a drawover system vaporizer

During drawover anaesthesia the patient moves, (or "draws"), air through the vaporizer which must have a very low resistance to the intermittent gas flow which is generated. The volume of air passing through the vaporizer is determined by the patient's tidal volume (the volume of air in a single breath) and the respiration rate. Considerable variations in flow through the vaporizer occur, depending on the type and depth of anaesthesia, the age of the patient and whether the patient is breathing spontaneously or being artificially ventilated. These conditions of gas flow require the drawover vaporizer to be specially designed.

Vaporizers designed for continuous flow anaesthesia should never be used in a drawover system as the high internal resistance to gas flow is too great. They are designed to work under a continuous high pressure and flow, and are called **plenum** vaporizers.

As air flows into the vaporizer it is directed either to the vaporizing chamber where it collects vapour from the volatile agent being used, or into a bypass chamber which does not come into contact with the volatile agent (figure 3). The air from the two chambers mixes as it leaves the vaporizer.

Figure 3



Vaporizer design

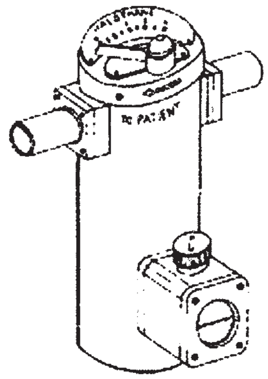
The ratio of air flow going to the different chambers determines the final concentration of volatile agent leaving the vaporizer, and is determined by the concentration control. The process of vaporisation removes heat from the volatile agent and vaporizer, due to the latent heat of vaporisation. This heat loss reduces the efficiency of vaporisation, and may result in a fall in concentration of volatile agent being delivered by the vaporizer. Some vaporizers compensate for cooling by a temperature operated valve which automatically increases the ratio of air directed through the vaporizing chamber as cooling occurs. Vaporizers with this facility are said to be thermo-compensated. Other vaporizers partially compensate for heat loss by containing a substance (such as water or copper) which delay changes in vaporizer temperature by providing a reservoir of heat. Vaporizers using this system are described as thermally buffered. Some vaporizers, such as the EMO, utilise both systems. ll vaporizers require regular maintenance, but schedules vary both in frequency and complexity. Some models can be maintained by the anaesthetist, provided the essential tools are available, others require to be returned to the supplier for maintenance.

The most widely available drawover vaporizers are the EMO (Epstein, Macintosh, Oxford), OMV (Oxford Miniature vaporizer) and the TEC series (previously known as the PAC series). A few details of the vaporizers are set out below; an article in the next issue of Update will describe their use more fully.

The **EMO** (figure 2) is a temperature compensated vaporizer which produces an accurate output of 0 to 20% ether. It is usually used in conjunction with the Oxford Inflating Bellows (OIB) which is incorporated as a part of the EMO system. Manufacturer Penlon (UK) Ltd.

The **OMV** (figure 4) is a small thermally buffered vaporizer which was originally produced to be used together with the EMO in order to speed the induction of anaesthesia. Original models contained only 20mls of volatile agent, more modern ones 50mls. A variety of volatile agents may be used with the OMV including halothane, trichlorethylene, enflurane, methoxyflurane and isoflurane. Different scales are available for each agent so that after draining the vaporizer the anaesthetist may use a different volatile agent. Manufacturer Penlon (UK) Ltd.

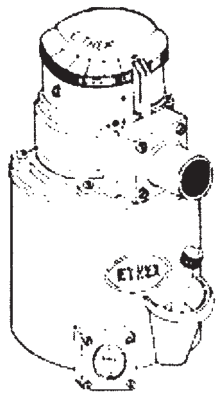
Figure 4



The OMV vaporizer

The **TEC or PAC** (figure 5) vaporizers consist of a range of thermo-compensated drawover vaporizers with different models available for ether, halothane, methoxyfiurane and trichlorethylene. Manufacturer-Ohmeda (UK) Ltd.

Figure 5



Ethertec vaporizer

Self-inflating bags or bellows allow controlled ventilation of the patient during anaesthesia or resuscitation. They should be the correct size for the patient to allow for an adequate tidal volume. Bellows and self-inflating bags incorporate a non-return valve through which they fill ensuring that fresh gas is always delivered to the patient. When there is an oxygen port on the bag or bellows this should be occluded, and oxygen added through a separate T piece (figure 2). Self-inflating bags and bellows are used with a non-rebreathing expiratory valve at the patient end to allow inspiration from the bag and expiration to atmosphere.

The Oxford inflating bellows (OIB) is popular with many anaesthetists using drawover anaesthesia. Unlike the self- inflating bags the OIB can be seen to move during spontaneous respiration. Two non-return flap valves are contained in the base of the OIB. The distal flap valve needs to be immobilised when the OIB is used with one of the non-rebreathing valves mentioned below. A magnet is supplied with the bellows for this purpose and its use will be fully described in a future article   Practical drawover anaesthesia.

Connecting tubing should be of the antistatic type when ether is used and connections conform to the international standards of 22mm and 15mm tapered connections.

Patient expiratory valve. This should be a non-rebreathing valve such as an AMBU El, Laerdel or Rubin's valve (figure 6). These valves allow either spontaneous or controlled respiration without adjustment. They need regular cleaning to prevent them becoming sticky and should be resterilised if used with a patient with chest infection.

Oxygen T attachment. To add oxygen to a drawover system a standard T piece is mounted on the intake side of the vaporizer (figure 2). If it is mounted on the output side of the vaporizer a dilution of the volatile agent will occur. A reservoir tube (at least a metre in length) allows oxygen to accumulate during the expiratory phase. An oxygen flow of one litre/minute results in an inspired oxygen concentration of around 30-40% and a flow of four litres/minute a concentration of 60-80%.

Figure 6