

DRAW-OVER ANAESTHESIA Part 2 - Practical Application

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In the first article on draw-over, Georg Kamm described the apparatus used in draw-over anaesthesia. In this issue, I want to describe the ways in which draw-over apparatus can be used to provide safe, high quality anaesthesia. We must first recognise that safe anaesthesia is not produced by apparatus alone!

The essentials for safe anaesthesia in any situation include adequate pre-operative assessment, preparation and resuscitation of patients, reliable intravenous access, a pleasant and safe induction, a secure airway, adequate tissue oxygenation, appropriate monitoring, and rapid recovery. None of these depends on high cost or high technology equipment, but all require properly trained and reliable people, on whom primary safety depends. If you are responsible for anaesthesia in a district hospital, and do not have extensive specialist training, you are well advised to use a small number of safe, widely applicable clinical techniques. This will allow you to become thoroughly familiar and confident with them through regular practice. No-one can be safe or confident when they use an unfamiliar technique. Restricting yourself to a small number of techniques also means that you use a limited number of drugs, and it is easier to make sure that adequate stocks are held in the hospital which do not run out.

A draw-over system is most suitable for the needs of district hospitals. It is simple to understand, robust, independent of compressed gases, and can be repaired on site if necessary. In a draw-over system the carrier gas (air, with or without oxygen enrichment) passes through a low resistance vaporiser, through a self-inflating bag or bellows and reaches the patient via a universal breathing valve which ensures that expired gases are directed into the atmosphere and do not re-enter the anaesthetic system.

Ether as an Anaesthetic Agent

Ether has largely disappeared from anaesthetic practice in Western countries, because of a number of apparent disadvantages: it has a pungent smell, and this combined with its high blood solubility

prolongs the induction of anaesthesia with ether alone. It has also been associated with post-operative vomiting, and people are concerned about possible dangers of fires and explosions. Nevertheless, ether has many important advantages - it increases cardiac output and is a respiratory stimulant - and is therefore the only volatile agent which can safely be used for spontaneously breathing patients if oxygen is not available. It is certainly the safest volatile anaesthetic in the hands of the inexperienced or occasional anaesthetist, and the experienced anaesthetist can easily use ether as part of a more sophisticated technique which avoids the problems of slow induction, vomiting, and delayed recovery.

Most of the disadvantages of ether are seen when it is used alone for induction of anaesthesia. They include a slow onset, an unpleasant smell for the patient, with coughing, breath-holding and laryngeal irritability, salivation, swallowing and sometimes vomiting. In the vast majority of patients, these problems can be easily and safely avoided by intravenous induction of anaesthesia with drugs such as thiopentone or ketamine. Insertion of an endotracheal tube secures the airway, and allows the concentration of ether to be increased rapidly to maintenance levels with no risk of laryngospasm. If a muscle relaxant is used, inhaled ether concentrations of 3-4% are enough to ensure unconsciousness, and wake up reasonably rapidly at the end of surgery. Ether also provides a considerably longer period of post-operative analgesia than other volatile anaesthetics. Thus, the clinical disadvantages of ether can be overcome, allowing us to make use of its advantages in safety, availability and economy. (A summary of a suitable technique for ether anaesthesia is shown in Table 1, Page 20). The only problem remaining is the question of its flammability.

Ether is flammable (will burn, but not explode) when mixed with air. In this respect you can compare it with alcohol, but not with petrol, which will explode when ignited in air. The addition of oxygen (or nitrous oxide) to ether does produce an explosive mixture, in which ignition could be caused by a source such as surgical diathermy, a sparking electric socket, or (especially in a dry climate) static electricity. Flammable or explosive mixtures must therefore be separated from possible ignition sources - there are two ways of doing this:-

Separation in time. Healthy patients are most likely to need added oxygen at the beginning of anaesthesia (before and just after intubation) and at its end (before extubation). At these times surgical diathermy is not in use. During the operation use ether/air without added oxygen unless the patient is very sick, old, very young or anaemic, or there are other indications such as pregnancy, cardio-respiratory disease or high altitude.

Separation in space. During the use of flammable/explosive mixtures no source of ignition is permitted in a "zone of risk" which extends 30 cm from all points of the breathing system where gas might escape - thus no diathermy in the thoracic cavity, head and neck, or mouth is permitted, but diathermy in the bladder or abdominal cavity is considered safe. A simple scavenging system - a length of tubing to direct the expired gases away from the site of surgery, is helpful. In dry climates (including air conditioning) anti-static precautions should also be used.

It is worth remembering that Western operating theatres are still mostly built with antistatic precautions, since even without ether there is a risk of fires and explosions with other substances mixed with oxygen (enflurane, trichloroethylene, alcohol etc.).

Using Other Volatile Anaesthetic Agents

Halothane is widely available, and has a number of advantages. It is non-flammable, has a pleasant, non-irritant smell, and induces unconsciousness more quickly than ether. Its disadvantages are that it depresses the cardiovascular and respiratory systems, resulting in hypotension and hypoxia. It is more potent than ether, and must never be given by "open drop" techniques. Halothane should never be put in an EMO vaporiser, as it attacks the metal from which these vaporisers are made, and the vaporiser will be wrecked! The most suitable draw-over vaporiser for halothane is the Oxford Miniature Vaporiser, which can also be used for other volatile anaesthetics if these are available (e.g. trichloroethylene, enflurane etc.).

Halothane can be used alone for anaesthesia; its main disadvantages in this situation is the respiratory depression which it causes, and supplementary oxygen should always be used throughout the procedure. If oxygen is not available, ventilation

should be assisted or controlled to prevent hypoxia. Halothane sensitises the heart to adrenaline, and you should warn the surgeon not to infiltrate the wound with adrenaline-containing solutions when halothane is in use. (Some anaesthetists allow infiltration of up to 20 ml of 1:200,000 adrenaline provided the pulse is closely monitored).

Halothane may be very useful in combination with other volatile anaesthetics. If you plan an inhalational induction, begin with halothane, then change to ether once the patient becomes unconscious - this is much quicker and more pleasant for the patient - and you will see the contrast between the respiratory depression of halothane and the stimulation of ether!

Halothane has also been used successfully for military anaesthesia in combination with trichloroethylene, using two Oxford Miniature Vaporisers in the "Tri-service" apparatus. The agents complement each other, since halothane is a good hypnotic but a poor analgesic, while the reverse is true of trichloroethylene. Use 0.5% trichloroethylene as a "baseline" and vary the concentration of halothane to obtain the required depth of anaesthesia. Turn the trichloroethylene off a few minutes before the end of the operation as it takes a while to wear off. Once again, added oxygen is necessary.

Draw-over Without Volatile Anaesthetics

Whichever kind of general anaesthetic you use, the patient must have a secure airway and adequate breathing. There is no reason why you should not use the draw over system to provide these in conjunction with a total intravenous anaesthetic. The invention of electronically controlled infusion pumps leads some to suggest that these may one day replace vaporisers for most anaesthetics - but in many situations a carefully regulated and monitored intravenous infusion of a drug such as ketamine can be given using an ordinary intravenous drip and a watch with a second hand.

Prepare a solution of intravenous anaesthetic to a standard concentration (e.g. ketamine 1000mg in a 500 ml bottle or bag of normal saline, equal to ketamine 2mg/ml). You will need to know the number of drops/ml of your giving set. Prepare your apparatus, give oxygen by facemask, and induce anaesthesia with a fast running infusion

(you will need about 120mg of ketamine - 60ml of the above dilution). When the patient has lost consciousness give a muscle relaxant and intubate the trachea. Reduce the infusion of ketamine to about 2mg/min of the above dilution according to clinical signs for maintenance, and give further doses of relaxant as necessary. You must monitor your infusion continuously - if it stops or becomes "tissued" the patient may become aware. At the end of anaesthesia reverse the relaxant, stop the ketamine, make sure the patient is breathing well and put them in the recovery position. Benzodiazepine premedication or postmedication will prevent dreaming and emergence reactions. The addition of atropine will reduce excessive secretions.

You can use a similar technique with other intravenous agents, but be warned that recovery after the use of barbiturate infusions may be very prolonged.

Oxygen Supplies

We have already noted some of the problems of oxygen supplies: in developing countries hospitals may have to purchase their own cylinders, and many of these go missing when sent for re-filling. With the draw-over system, missing cylinders do not cause the anaesthetic service to collapse, but oxygen is still very desirable, especially if your patient is very young, old, anaemic or ill.

The use of a T-piece (see Fig 1) to enrich a draw-over system is very economical and allows you to make the most of your supplies. A flow of 1 litre/min provides an inspired concentration of 30-40% oxygen; 4 litres/min provides 60-80%. To make the best use of oxygen post-operatively, or in cases of breathing difficulty due to respiratory infections

etc, use a nasopharyngeal catheter (eg a 8-10FG rubber or plastic catheter) inserted into the nasopharynx with a flow of 1 litre/min for a child or 2 litres/min for an adult, giving an inspired concentration of about 40% oxygen. It is desirable to humidify the flow of oxygen and vital to check that the catheter is not inserted too far (e.g. into the oesophagus) or gastric dilatation could result. As well as its economy, this method is preferred by many patients as it allows them to talk, cough, expectorate and eat - all difficult to do with a conventional facemask!

Other sources of oxygen are worth considering. Industrial (welding) oxygen is normally made by the same process as "Medical oxygen" - and indeed industrial oxygen is often made to a higher degree of purity! You must check your own local specification!

Oxygen concentrators (see Update No.1) can also provide a supply for draw-over or ward use. Concentrators compress room air to a pressure of 4 bar, then pass it through a zeolite column which absorbs the nitrogen, leaving up to 96% oxygen (the rest is argon). If excessive flows are demanded the concentration delivered falls off. Small concentrators, which meet the World Health Organisation's (WHO) standards can deliver 4 litres/min of oxygen (>90%) with a power consumption of around 350 watts (mains electricity or AC generator required). Concentrators are usually the cheapest way of getting oxygen - often 30-50% of the cost of cylinders. They require simple servicing every 5000 hours and an overhaul every 20,000 (equivalent in running time to about half a million miles for a car!). For details of WHO approved concentrators write to the author.

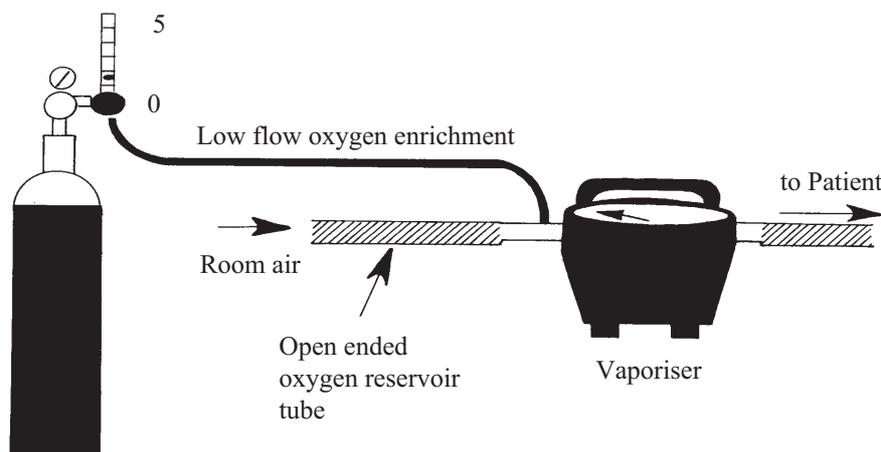


Figure 1. Adding oxygen to a drawover circuit

Table 1. Suggested plan for General Anaesthesia

Is General anaesthesia required for this case? \Rightarrow **NO** \Rightarrow Use regional technique



YES



Is the anaesthetist trained in endotracheal intubation? \Rightarrow **NO** \Rightarrow Use ketamine or spinal



YES



Has the patient a difficult airway? \Rightarrow **YES** \Rightarrow Use regional or seek expert help



NO



Proceed as follows:-

- .. Check your apparatus and drugs
- .. Obtain intravenous access and preoxygenate the patient
- .. Give a sleep dose of thiopentone or ketamine
- .. Give 1mg/kg suxamethonium i.v.
- .. Intubate the trachea
- .. Ventilate the lungs manually with 3% ether in air. Increase this during the first 5 minutes to 6-10% to settle the patient. (Halothane 1-1.5% can be used instead of ether).
- .. When breathing returns (usually after 3-5 minutes) allow the patient to breathe 6-8% ether in air or 1-1.5% halothane in oxygen-enriched air **or** if available give a long term relaxant (eg alcuronium or gallamine) and continue to ventilate the lungs manually, at an appropriate concentration of volatile agent (This technique allows rapid recovery).
- .. At the end of surgery reverse long acting muscle relaxants (if given) with neostigmine and atropine, continuing to ventilate the lungs until breathing resumes; turn the patient on his side, and remove the tube when the patient is awake.

This "universal" technique can be used for almost all types of surgery, and for both elective and emergency cases.

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If you work in a district hospital it is unlikely that you will have the help of a skilled technician to look after your apparatus, and the responsibility is therefore yours. No apparatus will work reliably unless it is properly and regularly inspected and cared for. Draw-over apparatus is not difficult to understand, and many simple procedures will prevent or correct breakdown. The first rule is not to interfere with apparatus which is working well! If you do have to make a repair, obtain a copy of the service manual, and make sure you have all the necessary spare parts and any special tools before you start.

Routine Care

Like all machines, your draw-over system requires regular attention to keep it in good, reliable working order. One of the main advantages of draw-over apparatus is that it is relatively simple to carry out these regular checks and simple repairs yourself - but remember that vaporisers and valves are precision instruments, and need to be handled carefully. Never use excessive force.

Make sure your apparatus is stored in a clean, dry place, away from dusty environments. Wipe it over regularly with a soft, moist cloth and a little detergent. Close off open ends with corks or plastic caps to prevent dust and insects getting inside.

Black (anti-static) anaesthetic breathing hoses are liable to perish in humid atmospheres; after use they will be wet inside from the water vapour in the patient's breath. After use hang them vertically in a cupboard to allow them to dry. Inspect them regularly looking especially for cracks in between the corrugations - this is where they most often develop leaks. If you do not use ether, you do not need anti-static hoses, and white polythene corrugated hoses are both cheaper and more resistant to humidity. Check your inflating bellows or Ambu bag for cracks or perishing in the rubber. These items are almost impossible to repair, so it is wise to have a spare in the supply cupboard.

Regularly inspect your Ambu (or other universal breathing) valves, and clean them when necessary. The inlet and exhaust ports can be unscrewed by hand, and the valve rubbers removed by gentle

pulling. Wash the inside and outside of the valve with warm soapy water, and allow the parts to dry thoroughly before carefully re-assembling the valve. Most Ambu valves can be sterilised, either with antiseptics or by autoclaving, but sterilisation is only necessary if the valve has been contaminated by use on an infected patient - for example one with tuberculosis.

When using the Oxford inflating bellows with an AMBU (or other universal breathing valve) ensure that you disable the flap valve nearest the patient using the magnet provided. This will prevent the valves from jamming during intermittent positive pressure ventilation.

If your anaesthetic facemasks have an inflatable margin check the state of the rubber, as it is likely to perish in time. If the small bung used to retain the air is missing it should be replaced with a suitable substitute - do not inflate the mask and tie a knot in the inflating tube!

Check your stock of endotracheal tubes regularly. Red rubber tubes are liable to deteriorate in hot and humid conditions. The inflatable cuff is especially vulnerable and should be tested before use.

Special Attention for Vaporisers

Drain and discard the contents of your vaporisers once a week, to avoid the build-up of deposits inside.

Vaporisers are precision instruments and must be treated with care. When complicated repairs are needed, the machine must be sent to a competent medical engineer or service centre, but there are a number of simple problems which you can deal with yourself. First of all, write to the manufacturers to obtain a service manual and any replacement parts you will need. When these have arrived, set aside a time when the vaporiser will not be needed for clinical use, and you have time to work on it. Below are brief descriptions of some of the operations you should be able to manage on Penlon vaporisers (EMO & OMV - the address is Penlon Ltd, Radley Road, Abingdon OX14 3PH. Telephone 44 235 554222 Fax 44 235 555252). Other brands of draw-over vaporisers generally need the attention of a service engineer.

The EMO Vaporiser - Common Faults

1. The pointer sticks and is difficult or impossible to move

Cause: build up of sticky deposits around the internal rotor drum.

Remedy: remove the drum and clean it; re-assemble the vaporiser.

You will need: Maintenance manual, screwdrivers, artery forceps, penetrating oil, ether, brass polish, vaseline and possibly a new main gasket.

2. The thermocompensator breaks - only the metal disc is visible in the window on top of the vaporiser.

Cause: metal fatigue after 5-10 years use.

Remedy order a replacement unit from the manufacturer. This is very simple to exchange for the broken unit - only a screwdriver needed to loosen 3 screws.

You will need: Screwdriver, replacement part.

3. Broken window of the filler gauge. Warning: you must not use an EMO with a broken filler gauge - it will give a dangerously high concentration of ether

Cause: accidental breakage.

Remedy: order and fit a replacement from the manufacturer. Fitting is simple - loosen 3 screws, remove the old unit and slot in the replacement.

You will need: screwdriver, replacement part.

Problems with the Oxford Miniature Vaporiser

OMV's used with halothane gradually become stiff to operate, due to the build-up of thymol (used as a preservative in halothane) in the mechanism. To clean this off properly you will have to take the top off the vaporiser. First obtain the service manual; you will almost certainly need to fit new rubber seals, so order these at the same time. A temporary "repair" can be achieved by pouring ether into the inlet and outlet ports, and gently working the concentration control from side to side. Do not use excessive force or you will bend it. The thymol will be dissolved by the ether. Afterwards, tip all the ether out, and ventilate with the bellows to dry out the vaporiser before re-filling it with the correct agent.

If you order a new OMV, remember that there are

many different models - be sure to specify which you want. The air inlet can be on the right (usually for draw-over) or left (for a compressed gas machine) and the tapers can be either 22mm ISO (draw-over) or 23mm cagemount (compressed gas machine). Make sure you know what you want before you order!

A video tape of the servicing of EMO and OMV vaporisers can be obtained from Dr Roger Eltringham, Department of Anaesthetics, Gloucestershire Royal Hospital, Gloucester, UK.

Technical Queries

Dr Ray Towey from Tanzania writes to ask:-

Q: "Is it possible to connect the outlet of the Puritan Bennett oxygen concentrator to an Oxford Miniature Vaporiser (OMV) to provide a continuous gas flow for an Ayres T-piece paediatric breathing system? My concern is that the outlet pressure of gas from the concentrator is too low to permit IPPV from an Ayre's T-piece".

Short answer: No problem, but the flow from the concentrator of 4 litres/minute means that with a fresh gas requirement of 150ml/kg/min you will be limited to using this system on patients under about 20kg - if you exceed this, rebreathing will be a problem.

Long answer: There are actually 2 questions to answer:

Q1: Does the OMV work efficiently with a continuous gas flow of 4 litres/min or less?

Answer: The OMV works **best** in the intermittent flow of a draw-over system, but with continuous flows its performance at 4 litres/min is satisfactory. If the flow is reduced to 2 litres/min it will give significantly less than indicated. I therefore recommend that you keep the flow at 4 l/min for all sizes of patients up to 20kg.

Q2: Does the back pressure generated by IPPV with a T-piece reduce the flow from the concentrator significantly?

Answer: No. Small concentrators like the Puritan Bennett and other WHO-approved models (Healthdyne & DeVilbiss) produce oxygen at a pressure of up to 5 p.s.i. (=0.35 bar, 260 mmHg, 340cm. water). The back pressure generated by IPPV is unlikely to exceed 30 cm. water, which is

only a tenth of that available. I have checked this in the laboratory using a P-B concentrator, and measuring the flow delivered through a high precision flowmeter while producing back pressure by applying a gate clamp to the oxygen tubing (see figure 1) with the concentrator flow control set to deliver 4 l/min.

Conclusions:

1. Flow from the concentrator is well maintained
 2. Even with significant back pressure, the flow indicated on the concentrator's flowmeter is a reliable guide to the flow actually being delivered.
- until back pressure reaches 60-100 mmHg (75-130 cm. Water). Results are shown in Table 1 below.

The results obtained were as follows

Table 1.

Flow from Concentrator	Back pressure applied	Actual flow delivered
4	0	4.25
4	15 mmHg	4.25
4	30 mmHg	4.1
4	45 mmHg	3.8
4	60 mmHg	3.8
3.5	100 mmHg	3.4
2	200 mmHg	1.75
1	300 mmHg	1.25
0	500 mmHg	0

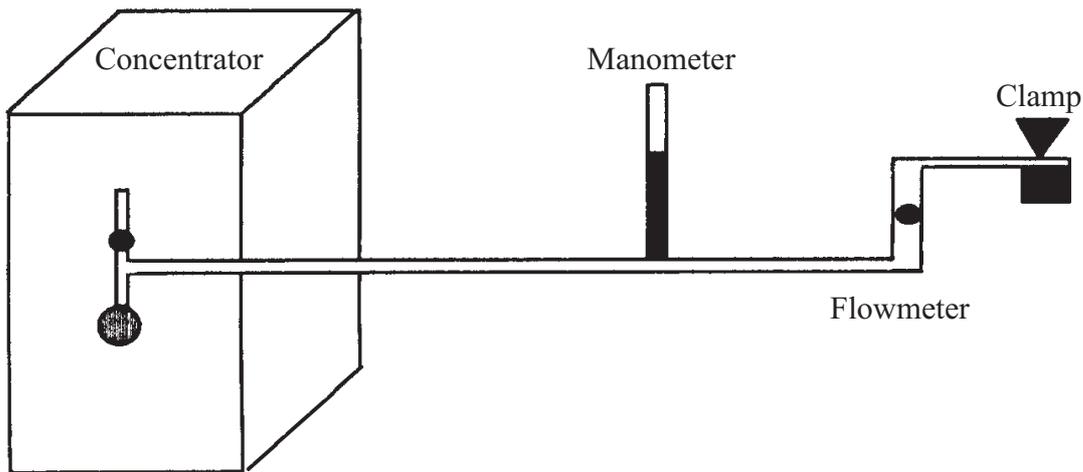


Figure 1.