A T-PIECE TECHNIQUE FOR GENERAL INHALATIONAL ANAESTHESIA

A SAFE METHOD OF REDUCING OPERATIVE BLEEDING

BY

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Anaesthetists are interesting themselves in the reduction of operative bleeding. One of numerous possible angles from which to attempt this—the lowering of the patient's arterial blood pressure—has received attention recently. To what extent this procedure may safely be applied remains to be seen. The object of this article is to draw the attention of anaesthetists to a simple technique of inhalational anaesthesia which, among other advantages, safely reduces operative bleeding, and, coupled with the intelligent use of posturing the patient, makes the use of drugs to lower the arterial blood pressure unnecessary on most occasions, since such bleeding as does occur is insufficient materially to influence the surgeon's operating conditions.

The technique described is a development of the T-piece technique of Ayre (1937a, 1937b), which was intended, among other things, to reduce vascular congestion during operative surgery. My technique differs from Ayre's in several respects. No additional apparatus is required, endotracheal intubation is unnecessary but may be used, nitrous oxide is the main agent used, air is excluded from the inhaled mixture, only minimal quantities of the volatile agents are used, a change to a semi-closed circuit can be accomplished in a matter of seconds, and the passage of gases through the "T" is different.

Ayre's Technique

Ayre's T-piece technique is briefly as follows. The apparatus consists of a series of tubes for the passage of gases connected together by a small T-shaped metal junction. A small flow of oxygen (2 litres a minute) carrying a high concentration of ether vapour is passed from an anaesthetic machine along some narrow-bore tubing through the vertical limb of the T junction into the horizontal limb (see Fig. 1). The proximal part of the horizontal limb is connected to an endotracheal tube through which gases enter the patient's lungs; the

FIG. 1.—Ayre's T-piece technique.

distal part is connected to a short length of wide-bore tubing which is open to the atmosphere. This part of the apparatus forms a small reservoir for oxygen, ether vapour, and gases from the last expiration. The degree of rebreathing can be controlled by varying the length of this distal piece of tubing. Thus expiratory valves and rebreathing-bags are dispensed with; the patient breathes oxygen, ether vapour, and air, at atmospheric pressure, with negligible resistance to inspiration or expiration. Resistance to expiration is a potent source of vascular congestion, and thus of increased operative bleeding. The only other available methods of inhalational anaesthesia which eliminate resistance to breathing are true "open-mask" techniques and insufflation techniques, both of which have distinct disadvantages which make them inferior to the T-piece technique.

Ayre's technique is probably unsurpassed as a method of inhalational anaesthesia for operations on small children about the head and neck; it has, however, a number of disadvantages which may account for its being seldom used for other types of operations. The disadvantages are: (1) Additional apparatus is required. (2) Some anaesthetists find that fitting the apparatus together is tedious. (3) Endotracheal intubation is necessary, and may not be justifiable for a minor type of operation. (4) A change to other techniques cannot readily be made. (5) Artificial respiration by inflation of the lungs cannot readily be achieved. As relaxant drugs are so commonly used, a means of inflating the lungs is often necessary. (6) Relatively large quantities of ether are required to maintain anaesthesia, as the vehicle is a mixture of air and oxygen. (7) There is an explosion hazard.

The following technique overcomes all these disadvantages and enables the T-piece principle to be used for any type of operation and any type of patient.

Modified Technique

The T in this technique consists of two large-bore lengths of corrugated tubing connected together by a large-bore metal T junction (on which is mounted an expiratory valve), as supplied as standard apparatus for any circle-type absorption unit. At the distal ends of

FIG. 2.—Modified T-piece technique, using endotracheal tube. The corrugated rubber tubing is shown as about one-third its correct length.

FIG. 3.—Modified T-piece technique, using facemask.

the rubber tubing are metal connexion-tubes. A mask, or endotracheal adaptor, is connected in the usual place. A high flow of fresh gases, 8 litres a minute, is passed through the apparatus; it consists of 75% (6 litres) nitrous oxide and 25% (2 litres) oxygen, with the vapours of any volatile anaesthetic agents as required (see Figs. 2 and 3). The two lengths of corrugated tubing form the horizontal limb of the T in this technique, and the patient takes gases from it via the vertical limb, which consists only of the facepiece mount; the passage of gases is thus somewhat different from that obtaining in Ayre's technique.

In practice, Boyle's apparatus is used as follows. The single corrugated tubing is detached from the usual semi-closed unit (Magill unit) at the junction just distal to the reservoir bag, and in its place, at this point, one end of the double-hosing unit is plugged in. A facepiece is attached in the usual place, and the other end of the double-hosing unit is left open to the atmosphere. The apparatus is now ready for use.

Boyle's apparatus fitted with a Coxeter-Mushin absorption unit can be used as above, or in a simpler way. The Coxeter-Mushin unit is in use, shall we say, as a semi-closed circuit, the soda-lime is turned off, the rebreathing dial is set at 50%, and 6 litres of nitrous oxide and 2 litres of oxygen are flowing, the anaesthetic being administered through either a facemask or an endotracheal tube. Now, if the hosing on the expiratory side is disconnected from the absorption unit and the open expiratory port plugged with gauze or a cork, the T-piece principle is in action. It is not necessary to alter the rebreathing control, as rebreathing cannot take place into the reservoir bag on account of a gravity valve on the inspiratory side. This valve is kept open by the high flow of fresh gases, and thus does not form any obstruction to inspiration in this technique. A small amount of fresh gases tends to accumulate in the bag, which is a desirable thing.

A Marrett apparatus can be converted in the same way, and a metal stopper is supplied with the apparatus for insertion into the expiratory port, though it is supplied for another reason. When the Coxeter-Mushin or Marrett apparatus is in use a change to conventional circuits is made by reversing the procedure, which takes only a few seconds. When Boyle's apparatus is in use a change to a semi-closed circuit is very simply made, by covering the open end of the hosing with the hand, the expiratory valve on the T junction being partly open. In either case manual inflation of the lungs is readily achieved.

By this technique air is prevented from entering the patient's lungs by the high rate of flow of fresh gases and the large volume of gases in the apparatus, which exceed the patient's minute-respiratory volume and his tidal exchange respectively, as the physics of the matter will show.

Physics

The volume of gas contained in the double rubber hosing unit is about 600 ml.—300 ml. on each side of the T junction. Let us suppose that the patient is breathing fifteen times a minute, and that his tidal volume (exchange) is 500 ml., a common occurrence when this technique is in use. His minute-respiratory volume is 7,500 ml. With a flow of 8 litres of fresh gases a minute, the patient's minute-respiratory volume is exceeded, and so no carbon dioxide can accumulate in the apparatus

except under the facemask. This can be ignored except when the patient is a very small child or when the tidal exchange is greatly reduced.

A flow of 8 litres of fresh gases a minute equals 133 ml. a second, or 532 ml. in four seconds. With a respiratory rate of fifteen a minute, the patient inspires once every four seconds. During these four seconds 532 ml. of fresh gases have entered the apparatus, and so the patient inhales 250 ml. of fresh gases from the inspiratory side of the rubber hosing from the reservoir bag, and 250 ml. of gases from the expiratory side of the rubber hosing, consisting partly of fresh gases and gases from his last expiration. In order to draw air into his lungs the patient will need to take a considerably deeper breath, for there is the dead space under the facemask, about 50–100 ml., and his own anatomical dead space, 150 ml., intervening between his lungs and the atmosphere. If, however, there is no reservoir bag on the inspiratory side of the apparatus the patient will take about 100 ml. of fresh gases direct from the flowmeters, 300 ml. of gases from the expiratory side of the hosing, and the remainder of his inhalation will be air. This would be a similar state of affairs to that in Ayre's technique.

A measure to prevent the entry of air into the lungs in this event, or if the patient is breathing too deeply, is to attach a further length of hosing to the expiratory side, in the shape of the single rubber hosing from the Magill unit which may be lying idle. It is important not to allow any air to enter the patient's lungs, otherwise the potency of the inhaled mixture is considerably weakened, as it is mainly nitrous oxide that is maintaining anaesthesia in this technique.

Clinical Application

In practice it is advisable to get the patient well settled by another technique before applying the T-piece principle, so that breathing is quiet and regular. For an adult intravenous thiopentone is excellent; for a small child an open-mask technique may be used. If an open-mask or semi-closed technique is used for the induction a quietening in the patient's breathing accompanied by a reduction in the amount of operative bleeding will usually follow the change over to the T-piece technique.

As an illustration of the technique, this would be the anaesthetic procedure for an operation such as a mastectomy. Premedication need only be light, with the customary doses of morphine and atropine, or "omnopon" and scopolamine. Induction takes place in the anaesthetic room with intravenous thiopentone, 0.25–0.5 g. being used as required; the syringe is left in place or a Gordh attachment is fitted to the needle. The patient is now transferred to the operating table. To get the patient settled further intermittent injections of thiopentone are given until he has received, say, 0.75–1 g. This will produce about ten minutes of surgical anaesthesia and a basal level of narcosis for about an hour in an average patient. During this initial period of ten minutes the patient will have been placed in position for operation, the diathermy pad applied, the skin prepared, the towels fixed, and the inhalational anaesthetic and operation started.

The facemask is applied as soon as convenient, with 6 litres of nitrous oxide and 2 litres of oxygen running. This concentration of nitrous oxide may be sufficient to maintain a very light plane of anaesthesia in some patients following the drugs previously given, but other agents will usually be required to prevent reflex response

to operative stimuli, such as movements of the limbs or face, laryngeal activity, respiratory changes, rise in pulse rate, and other phenomena. Any desired supplement may be used, according to the preference of the anaesthetist, such as low concentrations of trichlorethylene ("trilene"), "vinesthene," ether, or even cyclopropane (100–200 ml.); alternatively, further intermittent injections of thiopentone or injections of pethidine may be given. If trichlorethylene or ether is used it is only necessary to raise the lever of the Boyle's bottle to the top of the second division, plunger up. Changes in cardiac or respiratory rhythm are extremely rare when trichlorethylene is used, and this is probably the most useful supplement, as it is non-explosive and has a very potent analgesic action.

Should the patient's tidal exchange become inadequate for his metabolic requirements some degree of cyanosis will usually follow if his blood haemoglobin is normal, since the concentration of oxygen in the inhaled mixture approximates to that of atmospheric air: this is a safeguard against carbon dioxide accumulation in the patient which may follow shallow breathing—another common cause of increased operative bleeding. Cyanosis may be remedied by one of several methods: by increasing the rate of flow of oxygen or decreasing the rate of flow of the nitrous oxide, by adding 500 ml. of carbon dioxide to the flow of gases, by changing to a semi-closed circuit, and by assisting respiration by bag-pressure. These measures should not, however, be prolonged, as they will detract from the benefits of the technique, particularly as regards the quantity of operative bleeding.

Should the patient's breathing become too deep there will be a danger that air may enter his lungs, which will in turn be followed by a rapid lightening of anaesthesia, so that immediate action is called for. An injection of thiopentone will usually have the desired effect, but if this is not possible the flow of nitrous oxide should be raised temporarily to 8 litres, the concentration of supplementary agent increased, or perhaps an injection of pethidine made. If the depth of breathing is not soon decreased it is advisable to change to a semi-closed circuit until the patient comes under control, lest he should return to consciousness. The addition of a second length of rubber hosing to the expiratory side of the apparatus will also help to prevent entry of air into the lungs.

A rather useful point about this technique is that, by the simple expedient of applying the open end of the rubber hosing to his ear, the anaesthetist is able to listen to every breath that the patient takes; thus positive proof is continuously available that the patient is breathing adequately through a clear airway, or otherwise, as the case may be. This should be very useful during intracranial operations.

The technique has the disadvantage that comparatively large quantities of gases are used; but then these are very cheap compared with intravenous drugs. There is also the inconvenience of changing cylinders. Body heat and water vapour are lost by the patient to the atmosphere; but this loss is a totally normal occurrence, and is no greater than in normal breathing, and can scarcely be said to be harmful.

In addition to the advantages already mentioned, this technique makes the use of nitrous oxide and oxygen, with truly minimal quantities of supplementary agents, a practical proposition when the patient is a small child, and it has been safely and satisfactorily used on patients

as young as 1 year old. This is perhaps because there is the minimum of interference with normal physiological breathing. In this respect the technique compares favourably with open-mask techniques, and is recommended to those anaesthetists whose surgical colleagues insist on the use of "open ether" for such operations as thyroidectomy.

Summary

The use of the T-piece principle of inhalational anaesthesia is offered as a safe and satisfactory method of reducing operative bleeding.

Ayre's T-piece technique is briefly described and its disadvantages are mentioned.

A technique which overcomes these disadvantages is described.

An account is given of two simple ways of converting standard apparatus to the T-piece principle. No additional apparatus is necessary, but endotracheal intubation may be used. Nitrous oxide is the main agent; air can be excluded from the inhaled mixture. A change to or from a semi-closed technique can be accomplished rapidly.

The technique may be used for adults or children, and for any type of surgical operation.

The applied physics of the technique is outlined.

As an illustration, a typical anaesthetic for a patient undergoing a mastectomy is described.

REFERENCES

- Ayre, P. (1937a). *Lancet*, **1**, 561.
— (1937b). *Anesth. & Analg.*, **16**, 330.

Medical Memorandum

Leukaemia With Primary Gynaecological Manifestations

Although leukaemia in association with pregnancy has been reported and discussed in many recent papers, a search of the *Quarterly Cumulative Index Medicus* shows no report in recent years dealing with leukaemia from the gynaecological aspect. Therefore the admission to one hospital of three such cases as acute gynaecological emergencies in a short period appears to be worthy of record.

Case 1

An unmarried woman aged 22 was admitted on April 17, 1947, at her doctor's request as a case of pneumonitis complicated by abortion. She stated that she had had a cough all her life, that it had been worse for the past month, with pain in the right side of the chest, night sweats, but no sputum. Menstruation had always been normal and regular, but she had bled severely from the uterus for seven days preceding admission to hospital.

She was pale, weak, and very ill. Her blood pressure was 130/60. A faint macular eruption was present on both legs, from the thighs to the ankles. There were signs of consolidation at the right base of the lungs, and the tip of the spleen was just palpable. On rectal examination the cervix and uterus appeared to be normal. An immediate blood count was as follows: red cells, 2,350,000 per c.mm.; Hb, 40%; C.I., 0.79; blood group, A; white cells, 1,075 per c.mm. (polymorphs 33%, lymphocytes 64%, monocytes 3%); platelets very scanty; nucleated red cells, 25 per 100 white cells; bleeding time 10 minutes (normal by method used 1–2 minutes). A film of sternal marrow was reported as showing "great reduction in white blood cells; only a few polymorphs and myelocytes seen in many fields. There are a fair number of nucleated red cells of rather early