SESSION II

Pharmacological blockade

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Summary

Our technique is essentially one of pharmacological blockade achieved for the most part by a combination of ganglion blocking drug, halothane and β -adrenergic blocker. To these are added the effects of posture and controlled respiration to reduce systolic blood pressure to 60-80 mmHg at heart level. Initially this is seldom difficult, but the maintenance of a steady hypotension often needs an increasing amount of halothane together with a rising end-tidal positive pressure. This paper is restricted to technique, but it would be a mistake not to draw attention to the physiological limitations which this technique imposes. These are the circulatory changes in the brain caused by the steep head-up position and a low systolic pressure, and the altered ventilation : perfusion ratio within the alveoli of the lungs. These are the parameters of physiological trespass within which the technique must be practised if success is to be achieved with safety.

THE technique of hypotensive anaesthesia practised today at the Queen Victoria Hospital, East Grinstead, has developed gradually over 20 years expanding naturally from what John Gillies first so aptly termed 'physiological trespass' into what is now a combination of physiological and pharmacological controls. For several years it has been described under the headings of ganglion block, controlled posture and controlled ventilation and, although this is still fundamentally sound, it is better and certainly more instructive to use the term 'pharmacological' instead of 'ganglion block' because drugs acting on other parts of the autonomic nervous system are now often included. The technique is one of deliberate interference with circulatory auto-regulation, so that when the patient is challenged with posture and IPPV normal adjustments can no longer be effected, or they are weak and not well maintained.

Pharmacological blockade

The ganglion blocking drugs in common use, as with relaxant drugs, are either short or long acting,

and which to use is in many ways a personal choice. For plastic operations and those involving wide skin dissection, the choice would seem to lie with a long acting drug such as pentolinium tartrate (Ansolsen) for in this way the return of pressure is achieved more slowly, thereby assisting post-operative haemostasis.

The short action of trimetaphan (Arfonad) is favoured by some, more especially as one may extend its ultra-short action into more continuous control by the simultaneous exhibition of agents such as halothane and propranolol. Our technique with Arfonad is to avoid the continuous intravenous drip, using instead intermittent doses, usually 10 mg or less of a solution containing 10 mg/ml administered through a Gordh needle. In this way hypotension although subject to some fluctuations can be controlled at a reasonably steady level, whilst after operation blood pressure and vasomotor reflexes are quickly regained unless dosage has been high and the operation time prolonged.

These two ganglion blocking drugs are now used routinely, but it must be stressed that the hypotension obtained from any drug depends on many factors and is not produced by the ganglion paralytic alone. This is most important to bear in mind, because the power to produce and maintain hypotension resides almost entirely with the anaesthetist who can, by skilful use of gravity and controlled respiration, maintain almost any level of blood pressure according to the dictates of the surgery and the safety of the patient. The ganglion blocking action is necessary only in as much as it allows the anaesthetist access to these basic controls of posture and respiration.

Controlled posture

When the human body is tipped foot down, gravity causes blood to pool in the dependent vessels more particularly the venous reservoirs and hence venous return to the heart is reduced. This means that to achieve hypotension there must be dilatation of

the veins, the so-called 'capacity vessels', so that they can accommodate the extra volume of blood passed to them through relaxed arterioles after vasomotor paralysis. It must be remembered that blood flow through arterioles increases considerably after relaxation of their muscular walls, and should this blood return in normal volume to the heart, as when the patient is supine, the blood pressure will show little change. However, gravity acting on the tipped body causes blood to pool in dilated veins, thus diminishing venous return and so achieving hypotension. The level of hypotension will, of course, vary in proportion to the angle of tip.

A further effect of gravity on the tipped patient is to induce a gradient of arterial pressure throughout the body. Hence pressure above heart level will be reduced and below heart level it will be correspondingly increased. The difference, which can be calculated theoretically, is 2 mmHg for each 2.5 cm of vertical height. This means that when the body is tipped 25° foot down, the head is then elevated about 20 cm vertically above the heart, and the pressure in the cerebral circulation will be about 16 mmHg lower than at heart level. This further fall of pressure by gravity achieves a minimal blood supply to the elevated regions which, with the good venous drainage of this position, results in a considerable reduction of bleeding at operation. Hypotension should, whenever possible, be accompanied by a postural ischaemia in this way, for not only does it ensure a much drier operation field, it also enables pressure at heart level to be maintained at a higher level.

This reasonably acceptable explanation of the background of postural ischaemia gives the impression that here is a simple and straightforward technique for hypotension. This indeed is what we hoped with the early experiments of 1949–50, but we were soon to learn that the human body is neither simple nor straightforward for although the degree of hypotension induced in this manner could sometimes be extremely profound, nevertheless almost without exception, it was seldom maintained for any length of time. The need to maintain hypotension for the duration of surgery led, therefore, to the next advance which was that of respiratory control.

Intermittent Positive Pressure Ventilation (IPPV)

Controlled respiration not only prevents the 'suction and force pump' action of respiration maintaining blood pressure, it also controls venous return to the right heart and the capacity of the pulmonary vascular bed during positive pressure breathing. Increased airway pressure is transmitted to the vessels of the pulmonary bed and through the lung tissue to the great veins. By this means venous return to the heart is impeded, and the output of the

right heart into the pulmonary circulation is controlled. This is a sensitive regulator of blood pressure, particularly in the early stages of an operation when presumably the ganglion blockade is most effective. After a period of time, however, which varies considerably from patient to patient, IPPV ceases to be easily effective in controlling blood pressure and it is at this point that the help of other drugs is often required. Those which act on the heart and peripheral blood vessels are the most effective. Thus, as would be anticipated, halothane and β -adrenergic blockers are two of the most important additions to the hypotensive technique. Other drugs which may help at this juncture are thiopentone, muscle relaxants and methoxyflurane, but in practice little use is now made of them for this purpose.

Although this description has led up to halothane and β -blockers by stages, so to speak, it must be realized that their deliberate use in this manner to enhance and prolong hypotension has made such a significant difference to the success of the technique that they are now often used routinely. In patients who are resistant they ensure an adequate fall of pressure which would not otherwise have been achieved, and indeed at times they are the only means of obtaining a good result. In many cases they assist the smooth conduct of hypotension so that a steady level can be maintained more easily. They have become an integral part of a technique in which ganglion paralysis is the first requirement, although at times they may be responsible themselves for a major share of the hypotension.

Halothane

The hypotensive effect of halothane can be used either in conjunction with ganglion blocking drugs or on its own. When used as an adjunct to ganglion paralysis it is often extremely effective in low concentrations. The hypotensive effect of a vapour strength as low as 0.5% can sometimes be profound. Indeed, when sensitivity is great it is best to avoid halothane entirely during the early stages and to wait until blood pressure rises before it is used. It should be introduced first at minimal vapour concentration, and only increased thereafter in response to a rising blood pressure. Used in this way, it is seldom necessary to build up a concentration in excess of 2% whilst it is usually possible to maintain a steady hypotension with 1–1.5%. It should be emphasized again that hypotension induced in this way is primarily by ganglion paralysis.

The use of halothane during induced hypotension is now so commonplace as to make its early introduction almost routine. It must be emphasized, however, that if it is administered before ganglion paralysis is induced the patient's sensitivity thereafter (to posture and respiration) will be increased

considerably and unless great care is taken blood pressure may fall very low and sometimes in an uncontrolled manner. Obviously this should be avoided for it is not only potentially dangerous, but probably unnecessary for the operation. Sound practical advice is to limit the use of halothane as a precursor to ganglion blockade to patients below the age of 25 years, and even then not to use a vapour concentration in excess of 0.5%.

In the absence of ganglion blocking drugs halothane may be used alone to induce the required hypotension by a combination of peripheral vasodilation and myocardial depression. Because of the apparent ease with which hypotension can be achieved in this way it has become more widely practised, although with few exceptions it is often a difficult and sometimes an unrewarding technique. Although some fall of pressure almost invariably occurs as soon as halothane reaches the circulation, it is often inadequate to influence bleeding. To achieve this the necessary vapour concentration may have to be high and must be inflated under controlled ventilation whilst blood pressure will vary with the surgical stimulation and the patient's sensitivity. Control at a steady pressure level requires practice to obtain the necessary concentration of halothane in the body and, as this can only be changed slowly, blood pressure cannot be adjusted so easily or quickly as by the physical controls of posture and respiration. Furthermore, bleeding sometimes appears to be more profuse at any given pressure when hypotension has been induced by halothane alone. The advantages are that vascular control is not paralysed to the same extent as with ganglion blocking drugs and reflexes return more quickly when the concentration falls. In elderly or frail patients halothane alone can be sufficient to maintain an easy control of blood pressure, but in young patients this is seldom so unless high vapour concentrations are used.

It is our experience that hypotension is best induced by ganglion blockade in those patients who can be tipped into a foot down position and the operation site elevated, i.e. all head and neck and upper thoracic operations, and here halothane usually plays an important but mainly a secondary role except in those who are very old or frail. For operations elsewhere on the body, more particularly those within the pelvis, halothane gives a modest reduction of pressure and bleeding, and has the advantage that vascular reflexes are rapidly restored to normal after operation.

β -adrenergic blockade

The powerful negative inotropic action of propranolol and practolol is particularly advantageous in those cases where sympathetic tone is high, as in

children and young adults. The tachycardia which so often accompanies hypotension in these patients can be mostly prevented or attenuated by their action whilst their peripheral effects on vascular receptors enable venous reservoirs to remain dilated and hypotension easier to control.

For children and young adults (below the age of 25 years) both propranolol and practolol should be given intravenously immediately after induction of anaesthesia, before ganglion blockade is commenced. Both drugs should be injected slowly to avoid undue bradycardia, and the dosage is calculated on the basis of 0.035 mg/kg for propranolol and 0.14 mg/kg for practolol. It is best to avoid all inhalational anaesthetics other than nitrous oxide and halothane thereafter. When surgery commences there may be an initial breakthrough of tachycardia with some elevation of blood pressure, but this is usually transient, and in most cases the pulse resumes a rate of 80–100 within a few minutes and thereafter remains steady. In consequence the initial fall of pressure is usually satisfactory, hypotension can be maintained easily, and adjustments of pressure effected by alterations of posture and respiration.

Patients older than 55 years of age seldom require the help of β -blockers, but the occasional patient may show tachycardia and a poor hypotensive response, and in them a small intravenous dose of propranolol (0.25–0.5 mg) or practolol (0.5–1.0 mg) enables an easier and more successful control to be established. Both propranolol and practolol may cause severe bradycardia if administered on induction of anaesthesia in these patients.

Between the ages of 25 and 55 there is a diminishing requirement for these drugs and, as in older patients, it is therefore best given when needed—judgment being made on pulse rate and blood pressure. It must be remembered, however, that tachycardia will not respond immediately to β -adrenergic blockade and 3–5 min are usually needed to control an elevated pulse rate (and blood pressure).

During the last 7 years increasing use has been made of β -adrenergic blockers to assist and maintain hypotension in this way. Propranolol was the first drug used and it is still in use today, but practolol which has a much longer duration of action (2–3 hr) than propranolol (30–45 min) is now more often preferred. Their effect on bleeding, first noticed with propranolol, stimulated a study of skin vascularity (Enderby, 1970) in an attempt to explain why surgical fields often appeared to be improved out of proportion to the reduction of blood pressure. These investigations demonstrated that there can be a marked colour change in the skin following propranolol and for the vasodilated flushed warm appearance which often accompanies induction of

anaesthesia to become paler and cooler and more like that seen immediately before operation. In addition, the Triple response of Lewis, the natural skin reaction to injury, may show a marked reduction in vascularity with minimal flare and weal formation. More recent attempts to obtain similar results with practolol have failed, and it is tempting to think therefore that propranolol has a peripheral action on skin vascularity not shared with practolol and on theoretical grounds, therefore, it should be the agent of choice for skin surgery.

On the other hand, this difference is very difficult or impossible to detect by observation of the surgical

field when it is posturally ischaemic, and it is my impression that the quality of bleeding may be more influenced by pulse rate than skin vascularity. It is also claimed with some assurance that the negative inotropic action of practolol does not give as much anxiety as often attends the use of propranolol in like manner. It is tempting to think this may be due to the slight sympathomimetic action present in practolol but absent in propranolol.

Reference

ENDERBY, G.E. HALE (1970) *Proceedings of the 3rd Asian and Australasian Congress*, p. 338. Butterworths: London.