CIRCULATORY CHANGES IN ANAESTHESIA*

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The advent of modern anaesthesia has seen more than just the introduction of new drugs and techniques, for it has created a general desire in the anaesthetist to learn more about the physiological changes occurring in a patient undergoing surgery.

In England little over 10 years ago the anaesthetic agent of choice for most surgical cases was ether. Today the ether bottle stands on the shelf gathering dust. This rapid transformation has been brought about because we now know that we can provide better conditions for the surgeon with less risk to the patient by combining the use of different drugs. A start has been made on the road to learning some of the changes that take place in the circulation of the

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anaesthetized patient, but in the past this field has been so neglected that almost the whole physiological basis of the unconscious patient awaits discovery.

BLEEDING IN SURGERY

The rapid change-over from the era of ether to that of the muscle relaxant brought with it many problems, but foremost amongst these was the observation that the skin and muscle tissues showed increased oozing during operation. Plethysmography—that is the measurement of blood flow—revealed that there was an enormously increased flow of blood through both the skin and muscle tissues immediately a state of unconsciousness was induced. Experimental evidence suggested that the cause of this generalized vasodilatation was a temporary suppression of vasomotor activity. If the level of anaesthesia was kept constant, the blood flow returned to the normal level after about 40 minutes to 1 hour. It was found, however, that altering the depth of either ether or cyclopropane anaesthesia produced a profound change in the blood flow to the tissues. Thus, as the depth of anaesthesia increased so the blood flow diminished. This action is believed to be a local rather than a central one and to be mediated through either a direct effect of the anaesthetic substance on the vessel wall or the liberation of some constrictor substance.

The net result of these findings helps to explain why there is less bleeding in the presence of deep ether or cyclopropane anaesthesia than there is during light anaesthesia combined with a muscle relaxant.

Measures used to diminish Bleeding.

The problem of oozing from the surgical wound is clear. Prevention, however, is not so easy. *Deep anaesthesia*, employing toxic doses of anaesthetic agents, is effective, but this in turn leads to other complications. The anaesthetist, therefore, has tended to look around for some other suitable means of reducing 'anaesthetic ooze'. Local infiltration with a dilute solution of adrenaline in saline (1:250,000) is effective. Similarly, alterations in the carbon-dioxide tension of the blood influence the degree of capillary bleeding. A raised carbon-dioxide tension not only helps to raise the blood pressure and increase the cardiac output but also has a direct dilating action on the peripheral vessels. On the other hand, *hyperventilation* combined with carbon-dioxide absorption lowers the tension in the blood and reduces bleeding. Some anaesthetists in their enthusiasm for overbreathing the patient sometimes create a positive pressure within the chest during both phases of respiration. The result is that the flow of blood into the thorax is impeded and the cardiac output and the blood pressure fall. Although a positive intrathoracic pressure during expiration does help to reduce bleeding, the effects are so grossly unphysiological that it would not be used in clinical practice.

An outstanding advance in the reduction of bleeding in surgery was the re-discovery of the importance of *posture*. In the horizontal position none of the advantages of collapsed venous channels and capillaries can be obtained. The simple expedient of tilting the body 10°-15° from the horizontal in cranial, thyroid or certain plastic operations is often sufficient to curtail major oozing. Even under anaesthesia, however, the patient is still able to compensate for alterations in posture, and thus the blood pressure and cardiac output should be unaffected by this manoeuvre. Temporary interruption of this compensatory mechanism will seriously reduce the systolic pressure and consequently the bleeding in the upper half of the body. The desire for a relatively 'bloodless field' has led anaesthetists to search for satisfactory and safe means of producing these conditions. One of the ways of achieving them is to administer a *drug* capable of producing *peripheral vasodilatation* and to combine this with suitable posture so that the major part of the blood volume accumulates in the dependent part of the body, leaving the other half relatively dry. In short, the patient is bled into his own tissues. Nearly all the tranquillizing drugs are vosodilators, and one of the most potent is chlorpromazine. Intra-arterial injections of this drug have shown that it is very effective in producing a local vasodilatation which persists for 2-3 hours (Foster *et al*, 1954). Very large doses of these drugs are capable of producing some degree of block of autonomic activity but the principal action on the circulatory system is one of local dilatation.

Many authors have been tempted to claim that these drugs prevent surgical shock, and in so doing have created the impression that such an action is necessarily a beneficial one. If one concedes that the 'shock reflex', is merely a generalized vasoconstriction in response to haemorrhage or trauma, then it is certainly true to say that these drugs prevent this vasoconstriction from occurring. But if the signs of shock are merely an effort on the part of the body to guard against loss of body fluids, can anyone say that destruction of this line of defence is necessarily beneficial? It is a well-known fact that patients under the influence of vasodilator drugs tolerate blood loss very badly, and in the absence of a constrictor reflex even a small haemorrhage may prove fatal.

The quest for a greater control over the degree of blood during surgery has led to the introduction of the *ganglion-blocking drugs*. Opinion is strongly divided on the risks of using these drugs in clinical anaesthesia. At St. Thomas's Hospital in London we adopt a somewhat middle-of-the-road attitude and believe that in certain circumstances they have a very useful part to play. Thiophanium (Arfonad) combined with posture is the most frequently used. This technique is reserved for cases likely to suffer severe blood loss, such as block dissection of the neck, prostatectomy, Wertheim hysterectomy, and certain plastic procedures. The head-down tilt is favoured and the duration of hypotension is limited to the minimum time necessary for beneficial results. The presence of any signs of myocardial or cerebral ischaemia is taken as the only absolute contra-indication to the use of the technique; severe hypertension does not *per se* appear to lead to a harmful effect. As a safety factor it is of paramount importance that the systolic pressure should not fall lower than 70 mm. Hg. for more than a few minutes and under normal conditions the pressure is controlled around 80 mm. Hg. In the majority of cases this level gives very satisfactory operating conditions. Any blood loss must be instantly replaced by transfusion.

It must be stressed that rapid alterations in posture in the anaesthetized patient are dangerous, particularly in the presence of autonomic blockade. Whatever the angle, blood tends to accumulate in the most dependent part and a sudden alteration in position may lead to a fatal hypotension. Such an action is particularly severe in the absence of any powers of vasoconstriction. As a precaution against any such change in the circulation, any patient who has been submitted to a severe degree of tilt during operation is returned to the recovery room on a tilting trolley and only gradually, over a period of 2-3 hours after operation, is he returned to the horizontal position—and this only if the readings of pulse and blood pressure are within normal limits.

Haemorrhage and anaesthesia

That loss of blood leads to generalized vasoconstriction has been known for many years, but only recently was it deliberately adopted as a clinical practice for patients undergoing cranial surgery, in order to reduce bleeding and diminish the size of the brain. The technique was alternately to remove and replace blood from the radial artery to keep the systolic blood pressure at a level of 80 mm. Hg (Jackson, 1954). Though this practice never attained wide popularity, it stimulated other workers to study the effects of haemorrhage in the anaesthetized patient. One of the principal findings was that it was possible suddenly to remove up to 25% of the estimated total circulating blood volume without any significant change occurring in either pulse rate or blood pressure. Such a finding suggests that many patients may unwittingly be returned to the ward in a state of apparently normal circulatory balance yet, in reality, be suffering from severe hypovolaemia (depleted blood volume). Many of these cases show a marked hypotension and tachycardia in the immediate post-operative period.

Measurement of blood loss during surgery

The anaesthetist would clearly welcome a quick and simple means of assessing blood volume both before and after the induction of anaesthesia, but it will probably be many years before such a piece of apparatus is available. The simple expedient of weighing swabs, however, is easy to manipulate. A commercial spring-balance normally used for letters and light parcels is obtained and the scale is graduated, so that a zero reading represents the weight of 6 small, 3 medium and 1 large swab. The exact relationship in numbers must be determined at the outset. The scale is then graduated in millilitres of blood. In use, the nurse merely places the appropriate number of swabs on the scale and records the amount of blood present before proceeding to arrange the swabs. If a suction bottle is used this is also graduated in millilitres of blood. The surgeon must pay particular attention not to add fluid from extraneous sources, such as cysts, etc., to the total assessment. Some method of assessing blood loss in all cases of major surgery is essential, and at the present time the swab-weighing technique appears to assess the circulatory state of the patient with reasonable accuracy for clinical purposes.

SURGICAL SHOCK, STRESS AND ANAESTHESIA

The term 'shock' has probably led to more confusion of thought than almost any other in medicine today. Crile visualized surgical shock as a state occurring in the brain due to the constant bombardment of the brain by stimuli from the surgeon's knife. On the other hand there was the severity of the stimulus to be considered, and on the other the protection of the brain that was achieved by deepening the anaesthesia. If the degree of stimulus was too great for a particular depth of anaesthesia then a state of surgical shock supervened. The advent of d-tubocurarine has made this theory untenable, for we now know that it is possible to keep a patient in the lightest possible state of anaesthesia and yet perform the most traumatic operations without any signs of the development of surgical shock. It is most unlikely that this protection has anything to do with a specific action of curare on the brain or autonomic ganglia, as other relaxants with very different actions also offer this protection. I believe the shock syndrome is almost entirely due to alterations in blood volume, e.g. haemorrhage and dehydration. Rough handling of the viscera in a partially paralysed patient may be sufficient to induce a state of bronchoconstriction in the lungs and a tightening in the thoracic muscles, and this in turn may produce marked alterations in the pulse rate and systemic pressure. These changes are, however, rare in the completely paralysed patient on controlled repiration. Clearly certain visceral reflex pathways do exist, but we should not use the knowledge of their presence to explain errors of our own technique.

It is now almost universally accepted that all patients undergoing major surgery display the typical signs of the stress syndrome in the post-operative period—that is to say, they develop oliguria, sodium retention, leucopenia, etc. However, in 1955, Flear and Ruscoe Clarke showed in an experimental study in man that the degree of these reactions can be markedly reduced, or even abolished, with adequate transfusion therapy. It would be seen, therefore, that in the prevention of both 'surgical shock' and 'stress' it is most important to pay particular attenion to even minor alterations in blood volume during surgery.

THE ARRESTED CIRCULATION

The pressing demands of cardiac surgery for a completely 'dry field' are such that it is necessary to perfect some means whereby the heart can be omitted from the circulation for an hour or so without causing any damage to the vital organs. *Hypothermia*, by lowering the tissue metabolism, has offered one approach to this problem. I think it would be true to say that it has not lived up to the original expectations, but many successes have been achieved with this method. It is now generally agreed that it is unsafe to lower a patient's body temperature below 30°C (normal 37°C), and this level permits the surgeon only a very limited time to perform his repair (about 10 minutes). If, however, the danger of increased irritability of the heart at low temperatures could be removed, then the value of this technique would be enormously increased.

At the present time the most promising line of approach is by the use of a *machine* that will take over the work of the heart and lungs. But this alone raises many interesting problems of physiology, and offers an exciting new field of development, in which the anaesthetist will be required to play his part.

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