ANAESTHESIA IN OPEN HEART SURGERY

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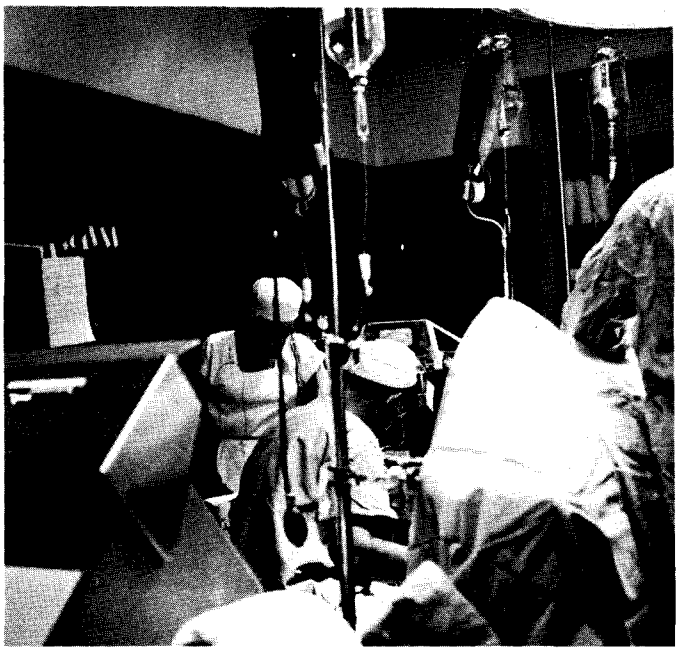


Function of the Anaesthetist:

It is often assumed that the main function of the anaesthetist is to render the patient unconscious with his anaesthetic; while from the patient's point of view this would seem to be very important, it is in fact one of the least exacting functions of the anaesthetist. His main concern in major surgery, as for example open heart operations, is to maintain the patient's physiological state to within as near normal limits as possible, despite the changes wrought by surgery, anaesthetic techniques and the disease process itself. The better the anaesthetist the more he anticipates these physiological changes, and the more smooth his anaesthetic appears.

Assessment of the Patient:

In order to anticipate these physiological changes, the anaesthetist must assess the patient as soon as possible prior to the intended surgery. A week or two in advance is ideal, but this is often rarely possible, In open heart surgery the assessment of the patient may be divided into several areas:

Assessment of the Patient's Heart:

This may be subdivided thus:

(1) Main pathology
- (a) Congenital defects
- (b) Acquired defects, (i.e. valvular etc.)
- (c) Coronary disease.

(2) State of the myocardium—This is assessed by a history or presence of dyspnoea, pulmonary edema and angina, and finally by the patient's general activity.

The Main Pathology is necessary to anticipate behavior under anaesthesia, as will be discussed later. The state of the myocardium is frankly an indication of the likelihood of survival under the stress of the surgery contemplated.

Coronary disease is often a serious complication, and a history of coronary thrombosis is an absolute contra-indication for surgery within three months, unless the surgery itself is in fact, a life-saving procedure. The mortality is enormous if one operates within this period.

General Assessment of Patient:

Anemia

The patient's general status is reviewed and particular attention paid to anemia. This in a marked degree can precipitate angina and obviously minor degrees of anemia can be quite important in patients with coronary vascular disease.

Electrolytes

Electrolytes must always be checked, particularly for potassium. Potassium ions are often deficient if the patient has been on a chlorthiazide type of diuretic. The importance of this is that the hypokalemic patient has a sluggish heart, a low blood pressure, postural hypotension and an inability to respond to stress, an obviously unacceptable complication for any elective surgery. The correction takes days because one must remember that the serum potassium (which is all that is measured), accounts for only 2% of the total body potassium. Attempts at rapid replacement will provoke dangerous hyperkalemic responses from the heart.

Low potassium also enhances the action of digitalis, an obvious complication in patients who are on that drug.

Enlarged Liver

The presence of a large liver should be noted and is frequently found in congestive heart failure, tricuspid incompetence etc. If the liver is palpable and large it is hardly likely to function efficiently, and one must remember that the liver is the body's carburator and the drugs given to the patient may not be broken down as readily as normal. Hence untoward effects may result from the administration of drugs that normally would be fairly safe, narcotics being particularly dangerous in this respect.

Teeth

Finally, not to be omitted is the state of the patient's teeth. These are frequently septic and a potent source of infection during and following surgery, and they should be removed if carious, and/or otherwise repaired, long before surgery under an antibiotic cover if necessary. The anaesthetist should also consider whether there will be any benefit from further treatment prior to surgery, and if so it is imperative to postpone surgery until the patient is in the optimum condition.

Preoperative Sedation:

Preoperative sedation is important and necessary for two reasons:

(1) It is only kind to see that the patient is adequately sedated preoperatively, unless of course the

patient is too ill to care.

(2) It will prevent acute cardiac failure supervening due to the prevention of anxiety, which in itself causes:
   (a) tachycardia
   (b) hypertension

First, it must be remembered that the optimal heart rate for patients with valvular disease is of the order of 70-90 beats perminute, and in those cases tachycardia of say 120 can precipitate acute congestive cardiac failure.

Second, hypertension increases the work load of the heart many times and it also must be remembered that the coronary flow is inversely proportional to the cardiac output, because maximal coronary flow occurs in early diastole. Hence a tachycardia and increased blood pressure not only increase the work load of the myocardium, they also reduce its blood flow and hence oxygen supply.

Induction

The risk must be remembered, when giving intravenous pentothal, of an air embolism in A.S.D.'s and V.S.D.'s. A few cc s of air that have crossed from the right to the left side of the heart and then lodged in a coronary or cerebral vessel, will produce an impossible situation which is entirely preventable. Meticulous care must be given to the setting up of intravenous equipment eliminating bubbles from the tubing and syringes.

When including anaesthesia with pentothal the anaesthetist must remember that these patients often have an extremely slow circulation time. If this is not borne in mind, there is a real risk of giving an overdose simply because a small dose given does not seem to have much effect within the usual time. Thus subsequent doses are added still without effect, a total dose of some magnitude being given. Suddenly the patient responds to the first dose, followed by the subsequent supplements with possible disastrous results.

It might be wondered why pentothal and in fact most of the other anaesthetics should be so lethal to these patients, if not handled with care and in very small doses. The reasons are simple. These patients have a low cardiac output which they are unable to readjust to any changes in their state that may occur. Pentothal has a profound effect on the cardiovascular system from its effects on the brain center, and also directly on the myocardium and the peripheral vaso motor tone.

The sequence of events given a relative overdose of pentothal or other anaesthetic therefore is:

Blood pressure drops due to peripheral dilation.
Hence the coronary flow is decreased.
Hence there is a poor left ventricular beat.
This in turn gives rise to diminished cardiac output (which may drop to nothing).

These effects of pentothal that have just been described can be most serious in any of the following conditions, which give rise to a low fixed cardiac output.

Causes of Low Fixed Cardiac Output:

(1) A failure of the left ventricle to fill out adequately. (Mitral stenosis, chronic constrictive pericarditis, pulmonary stenosis and large A.S.D.'s)
(2) Obstruction to left ventricular outflow (aortic stenosis).
(3) Pure left ventricular (myocardial) failure and coronary disease.

This is often combined with severe peripheral vasoconstriction, (i.e. these patients are in a shock like state).

Maintenance

Although several different anaesthetic agents can be used for maintenance, halothane is one of the commonest agents used. Its main advantages are: it is non-explosive and non-flammable in normal usage and it is quickly taken up by and removed from the patient so one can have a very precise minute by minute control of the depth of anaesthesia. Its powerful physiological effects must not be overlooked, one of the main ones being the effect on blood pressure. Halothane blocks the action of endogenous noradrenaline which gives rise to vasodilation, however assuming the coronaries are being well perfused, the cardiac output is often not as diminished as one might expect.

Acidosis:

During the course of the anaesthesia one area which must be watched very carefully is the blood gases. Acidosis is often present in these patients and if marked must be corrected. pH below 7.1 results in diminished cardiac output and increased cardiac irritability. Also the increased pulmonary vasoconstriction in some adults can be very marked, this being especially so in children. I have heard of one case where pulmonary vasoconstriction due to acidosis was sufficiently severe to mimic severe pulmonary embolism.

Positive Pressure Ventilation:

Squeezing the bag on the anaesthetic machine looks a pretty innocuous past-time. However, it is not without deleterious side effects.

(1) It exchanges the negative inspiratory pressure on inspiration with a positive pressure. This reduces or prevents the venous return of blood into the great veins in the thorax and atrium. It also increases the resistance to outflow from the right ventricle. It is very easy therefore to obtain a complete stasis of the circulation in patients who already have a right ventricular outflow obstruction as is found in pulmonary stenosis.

In tetralogies this is even more marked because of the concomitant reduction in peripheral vasospasm and hence lowering of pressure in the left ventricle which further encourages the right to left shunt. This effect can be very marked and one is often faced with tetralogies that become more cyanosed under anaesthesia breathing oxygen than they were breathing room air by themselves on the ward. A very frightening experience at the

best of times, but much worse if one does not understand what is going on.

(2) In healthy lungs air forced down the trachea will expand all the areas of the lung evenly. In unhealthy lungs there are areas which are more diseased (i.e. more rigid) than others. When the ventilating bag is squeezed too quickly the more compliant, that is to say the less rigid areas of the lungs, will be overdistended, and the more rigid or less compliant areas of the lungs will not be ventilated at all. Hence intrapulmonary shunts are formed with a reduction in the gaseous exchanges of the blood which normally take place in the lungs. This can be minimized by a gentle and careful ventilation.

However, raising the intra-bronchial pressure has one beneficial effect. It is the ideal treatment of pulmonary edema.

Blood Replacement:

It has been noted that these patients are often in a shock like state, and hence blood replacement is essential. It is though often very difficult to maintain the critical balance between too little blood being transfused with hypovolemic shock supervening, and too much blood with the precipitation of congestive cardiac failure. Often less than a unit of blood lies between these two extremes. Another point to remember is that in anomalous pulmonary drainage an increase of pressure in the right atrium from, say a rapid transfusion, will be transmitted directly to the pulmonary veins and hence to the lungs and may precipitate pulmonary edema.

A.C.D. preserved blood solutions are hypotonic. This causes the red cells to swell by 20%, which makes them fragile and for this reason some anaesthetists prefer not to give blood transfusions before and during pump runs unless absolutely necessary. This minimizes damage to the red cells, the pump oxygenator being much more traumatic than the patient's own circulation.

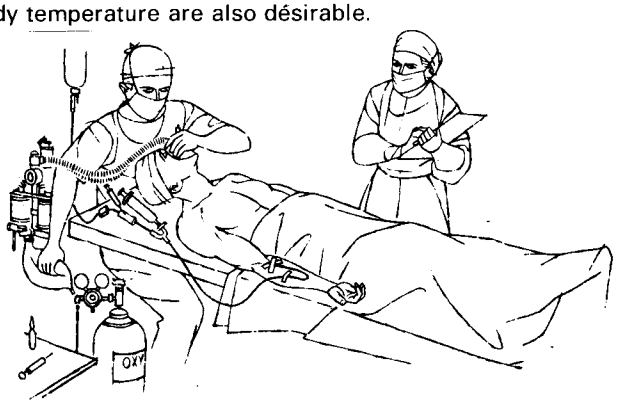
The large size of the red cells may cause obstruction in the micro circulation of vasoconstricted patients.

Transfused blood if given quickly or in a large quantity should always be warmed, otherwise inadvertent hypothermia will result.

Monitors:

Accurate and reliable monitors of the state of the patient are absolutely essential for the anaesthetist. Of these the electrocardiogram is obvious, direct arterial pressure is also essential in all major cardiac work and a central venous pressure is extremely valuable, being a fairly good guide to blood replacement.

Blood gases have been mentioned before and without them it is not possible to efficiently treat many respiratory and metabolic problems which arise. Temperature probes to measure body temperature are also désirable.



Finally, an often neglected monitor but one which can be invaluable in open heart work, is the electroencephalogram. This only indicates whether or not the brain has had its function interfered with. It does not indicate what the cause of this interference is, but this is usually immediately apparent.

It is extremely valuable on the odd occasion when it indicates, due to shunts in the patient (all other things being excluded) that the pump perfusion is inadequate. All other parameters appearing normal. Persistence of surgery under these conditions without increasing the pump flow would result in a patient with a permanently damaged brain. If one could only have one monitor to do open heart surgery, this is the one monitor that I would choose, being the one measuring the activity on the part of the body most sensitive to oxygen and blood lack.

Vasopressors:

Their use is at the best doubtful in this type of surgery. Isuprel is sometimes used to stimulate the heart coming off bypass, but I am not convinced that its apparent benefit is merely derived from the passage of time and the further elimination of the anaesthetic agent used while on bypass with resultant improvement in myocardial tone.

(See Page 16)

Continuation of Anaesthesia in Open Heart Surgery

Hypothermia:

Hypothermia is of little value now-a-days with the efficient pumps that are available, although at one time it was a useful adjunct to cardio-pulmonary bypass. However, inadvertent hypothermia is of frequent occurrence. Patients rapidly lose heat from evaporation and loss of skin insulation when their major cavities are opened, and it is not uncommon to have the patient returned to the recovery room two or three degrees below normal temeprature.

This cooling may reach a dangerous degree if in addition several units of unwarmed blood have been given during the course of the surgery. This results in a violent shivering as the patient emerges from anaesthesia in the recovery room.

While this is often tolerated fairly well by the healthy patient, a patient with a poor cardiac output cannot tolerate this and becomes acidotic in a very brief period. This may result in cardiac arrest from the severe degree of acidosis so formed. The chances of this occurring are minimized by using blood warmers during transfusion.

Postoperative Care:

Due to the fact that the lungs have been collapsed and often compressed by retractors during the course of surgery, intrapulmonary shunts are present many hours following surgery. Therefore all patients who have had thoracotomies should have oxygen postoperatively.

Also, sedation is indicated for the same reason as preoperatively and is particularly important in patients with known coronary disease, in order to protect them against the stresses and anxiety of pain. It is not unknown to have coronary patients awaken in the recovery room, complain to the nurse of pain, and expire before the analgesic was given.

All patients who have had major cardiovascular surgery, or who have poor myocardiums, will normally be put on positive pressure ventilation. This is applied either directly through a tracheotomy tube or more usually through a nasotracheal tube connected to a ventilator, and frequently cycled by the patients themselves.

Apart from the obviously severely ill patient, four other indications for putting patients on positive pressure ventilation postoperatively are:

(1) If there is a history of or a likelihood of pulmonary edema.
(2) If the $pO^2 = 60$ mm. Hg. or is dropping.
(3) If it is obviously hard work for the patient to breath. It should be remembered that in these cases, the work of breathing may equal 30% of the cardiac output.
(4) If the surgery finishes late at night. (The depleted night staff may find it hard to monitor these patients as adequately as in the day time, and the possible need of the patient is thus anticipated.)

Tracheotomy:

Generally speaking it is probably wise to restrict the use of the endotracheal tubes to three days, provided the tubes can be suctioned adequately, which is not always easy as it is sometimes very difficult to pass a catheter through their entire length and adequately aspirate the trachea. After this period it is usually safe to do a tracheostomy, the mediastinum now being sealed from the tracheostomy scar which is always an inevitably dirty wound.

Humidity:

Another fact not to be forgotten during both anaesthesia and in the postoperative period when the patient is on ventilators, is that the oxygen and anaesthetic gases are completely dry and there is no measurable amount of water vapor in them. As a result if these gases are conveyed by an endotracheal tube straight into the trachea, the normal humidifying mechanisms of the body are bypassed. This results in a drying out of the trachea, with the resultant destruction of the cilia and formation of mucous plugs condusive to obstruction and infection of lung segments.

Conclusion

The role of the anaesthetist in open heart surgery is therefore to asses the patient's needs prior to surgery and ensure that the patient reaches the operating room in the optimum condition, To anticipate the changes in the patient's physiology due to the disease process itself and those brought about by surgery and anaesthesia, and minimize them using the most suitable techniques and agents and finally to be responsible for the patient's respiratory care in the immediate postoperative period.

EXAMINE YOUR COMPREHENSION

You have only three minutes to finish this test.

1. Read everything before doing anything.
2. Put your name in the upper right hand corner of this page.
3. Circle the word "name" in sentence two.
4. Draw five small squares in the upper left hand corner of this page.
5. Put an X in each square
6. Put a circle around each square.
7. Sign your name under the title.
8. After the title write "Yes, Yes, Yes"
9. Put a circle around each word in sentence No. 7.
10. Put an X in the lower left hand corner of this page.
11. Draw a triangle around the X you just put down.
12. On the reverse side of this page multiply 703 by 9805.
13. Draw a rectangle around the word "page" in sentence No. 4.
14. Call out your first name when you get to this point in the test.
15. If you think you have followed directions up to this point, call out "I have".
16. On the reverse side of this page add 8950 and 9850.
17. Put a circle around your answer. Put a square around the circle.
18. Count out loud in your normal speaking voice backwards from ten to one.
19. Now that you have finished reading carefully, do only sentences one and two.