

On the 50th anniversary of the world's first heart transplant we are reprinting two of the articles that appeared in the *SAMJ* of 30 December 1967. These, the list of members of the heart transplant team, photos reproduced in this issue and the editorial by Brink *et al.* go some small way towards marking an event that was pivotal in the history of medicine.

CARDIAC TRANSPLANTATION—THE ANAESTHETIST'S VIEW : A CASE REPORT

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Are there any specific anaesthetic problems in providing anaesthesia for this type of operation? This is a difficult question to answer without discussing the obvious points about the patient being well-prepared, being given plenty of oxygen and blood replacement to run *pari passu* with loss. It must be realized that the adult patient who is selected for cardiac transplantation will always be a patient with a dying heart. There is no point in undertaking the operation in a patient without this condition, except perhaps in the case of cardiac trauma.

PROBLEMS ASSOCIATED WITH ANAESTHESIA

The problems may be regarded as falling into groups:

1. Sustaining the patient until the donor becomes available. This is properly the province of the physician-cardiologist rather than the anaesthetist.
2. Resuscitating the donor. In our present society, the patient is more than likely to be the victim of a motor-car accident or a gunshot wound. Such a patient will almost surely need resuscitation so that vital functions can be maintained and the donor organ kept in the best possible state until the transplant team is able to take action.
3. Anaesthetizing the recipient in order to enable him to be placed on the cardiopulmonary bypass machine.
4. Management during the bypass.
5. Management while coming off the bypass.
6. Management during the retreat from surgery.
7. The return to the ward and the care to be given in the immediate postoperative period.

The last 5 problems are those that regularly confront any anaesthetist involved in routine bypass surgery.

CASE REPORT

The Recipient

L.W., a White male aged 54 years, whose height and weight were respectively 1.65 metres and 58 kg., was seriously considered as a candidate for cardiac transplantation approximately 3 weeks before 3 December 1967. From that time onward he was a potential recipient and an attempt was made to ensure that he was in the best possible condition for surgery. His cardiac condition was such that he had had 3 episodes of myocardial infarction and these had resulted in an aneurysmal dilatation of his left ventricle. He had diabetes and also cellulitis of the left calf. Relevant medicinal therapy as at the night of 2/3 December 1967 was:

- Digoxin 0.25 mg. *b.d.*
- Prednisone 10 mg. 3 times per week.
- Lasix 40 mg. *b.d.*
- Slow-K tabs. 2 *t.d.s.*
- Librium 10 mg. *t.d.s.*
- Diabinese 1½ tabs. *b.d.*

Ethacrynic acid 50 mg. 6-hourly.
Gentamycin for the infection of his calf.

The Donor

D.D., a White female aged 24 years, was knocked over by a motor car, 1.5 kilometres from the hospital, shortly before 4 p.m. on 2 December 1967.

THE TIME SCHEDULE

4 p.m.

The donor was admitted to Groote Schuur Hospital with cerebral damage and multiple fractures of the pelvis and lower limbs. Deeply unconscious, her blood pressure was 60/0 mm.Hg, CVP -2 cm.H₂O and pulse rate 120/min. Resuscitation was begun by the multiple injury service and she was eventually admitted to the cardio-thoracic ward at 9 p.m., as a potential cardiac transplant donor.

10 p.m.

She was seen by the anaesthetist for the first time when she was found to have a blood pressure of 60 mm.Hg. She was now being ventilated mechanically via an oral endotracheal tube. The endotracheal tube was found to have intubated a bronchus and was withdrawn in order to lie in the trachea. Further blood transfusions and the administration of calcium gluconate and sodium bicarbonate resulted in a rise of blood pressure to 110 mm.Hg and a venous pressure of 3-4 cm.H₂O. The ECG, as monitored on an oscilloscope, was normal. The patient was seen by a neurosurgeon, who considered her cerebral lesion as lethal and beyond treatment.

12.45 a.m.

The donor was removed to the operating theatre and placed on the theatre table, artificial ventilation being continued all the while. ECG monitoring and mechanical ventilation were resumed. Blood pressure at this stage was 95-100 mm.Hg.

12.50 a.m.

The recipient was brought to the anaesthetic induction room: blood pressure was 130 mm.Hg and pulse rate 90/min. Atropine, 0.6 mg., was given intravenously, as a result of which the pulse rate increased to 100/min.

12.55 a.m.

Anaesthesia was induced with thiopentone, 200 mg., given slowly; the circulation time was found to be prolonged to over 2 min. Succinylcholine, 100 mg., followed and fasciculations ensued after some considerable time. In the interim, oxygen was being administered to the patient by way of an anaesthetic face mask and artificial ventilation. An oral endotracheal tube was passed into the trachea

and the patient moved into the operating theatre. Blood pressure at this stage had fallen from 130 to 110 mm.Hg and the pulse rate was 80/min. Anaesthesia was continued with nitrous oxide, oxygen and intermittent halothane; blood pressure and pulse rate remaining satisfactory. IV infusions were set up in both arms and the bladder was catheterized.

1.30 a.m.

The operation commenced with the right groin incision.

1.40 a.m.

Chest incision.

2.05 a.m.

Heparin given and the femoral artery cannulated.

2.20 a.m.

Artificial ventilation of the donor ceased.

2.32 a.m.

Cardiac arrest of the donor occurred, at which stage incision of the donor commenced.

2.32 a.m.

Cardiopulmonary bypass of the recipient commenced: flow 2.5 l./min. A bubble oxygenator was used, primed with 6 units of citrated blood diluted with 900 ml. Plasmo-lyte B solution (Baxter) and 900 ml. invert sugar, 10%, in Ringer's lactate solution with tromethamine (THAM-E) 12 G, calcium chloride 3 G and heparin 18,000 units added. Oxygenation and CO₂ elimination was accomplished by passing 100% O₂ through a halothane vaporizer and then into the oxygenating columns. Intensive cooling of the patient was accomplished by means of the heat exchanger of the bypass machine, and the oesophageal

temperature of the patient fell rapidly. The pressure on the arterial line was found to be excessive—up to 300 mm.Hg—and so, assuming femoral artery obstruction, the arterial inflow was changed to the aorta. Satisfactory mean line pressures of 100-140 mm.Hg resulted from a flow of 3 l./min. with venous pressures in the neighbourhood of 0 cm.H₂O (Fig. 1). During the bypass period, potassium chloride, 1 G/hr., was infused into the patient and sodium bicarbonate was given using the base excess of 'Astrup' determinations as a guide (Table I).

3.01 a.m.

The donor heart arrived in the recipient's theatre.

4.29 a.m.

The lowest oesophageal temperature of 21.1°C was reached.

5.19 a.m.

With both oesophageal and rectal temperatures at 22.8°C, rewarming of the patient by means of the bypass machine commenced and an isoprenaline infusion was set up.

5.43 a.m.

The transplant was completed.

5.52 a.m.

With oesophageal and rectal temperatures of 35.4°C and 28.1°C respectively, succinylcholine was given and then a DC defibrillation shock of 20 watt/sec. resulted in defibrillation and a cardiac contraction rate of 120/min. (Fig. 2). Warming continued.

6.06 a.m. - 6.13 a.m.

Three trials of unassisted circulation were made and at the third attempt, with oesophageal and rectal temperatures

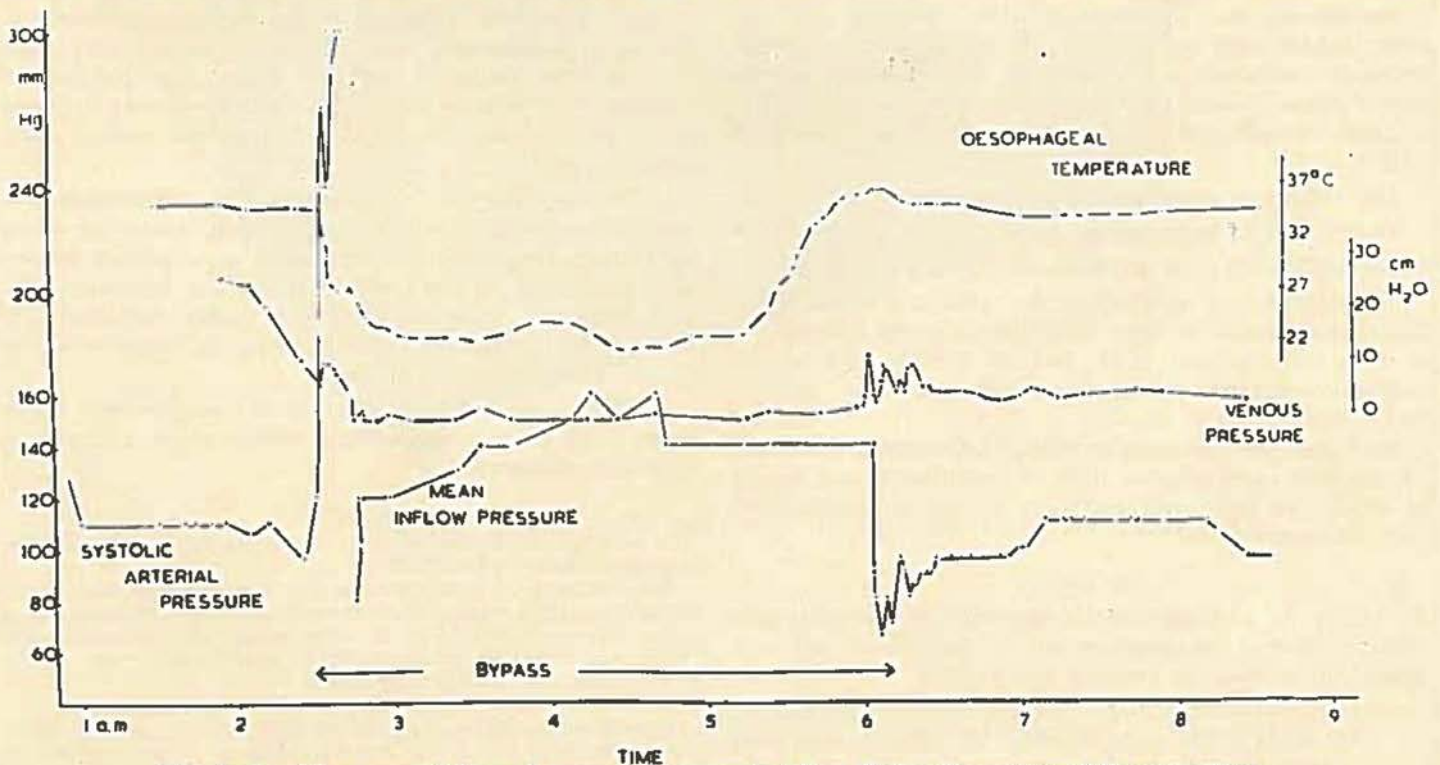


Fig. 1. Graphic representation of some measurements taken during the course of the procedure.

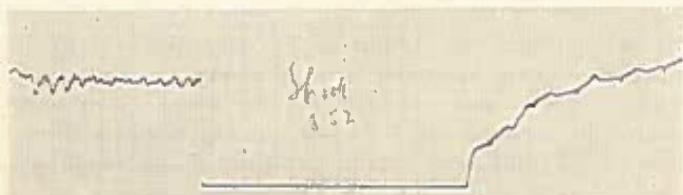


Fig. 2. Defibrillation of the transplanted donor heart.

of 35.5°C and 32.4°C respectively, and a venous pressure of 7 cm.H₂O, bypass was terminated with an arterial pressure of 95/70 mm.Hg. Calcium gluconate and isoprenaline were infused and the blood pressure, after settling at 80/60, gradually rose, at first to a systolic of 90 mm.Hg, then 95 mm.Hg and finally 110 mm.Hg. The venous pressure meanwhile stayed in the region of 5 cm.H₂O, and the oesophageal and rectal temperatures gradually equilibrated, while the warming of the patient was continued by circulating warm water through the blanket on which he was lying. Protamine to neutralize the heparin, potassium chloride, isoprenaline and blood were infused.

7.10 a.m.

Forty units of insulin were given subcutaneously because of the patient's diabetes.

7.13 a.m.

A very slow infusion of Lignocaine, 0.2 mg./min., was started.

7.18 a.m.

Pethidine, 25 mg., was given intramuscularly to depress any shivering that might occur and also to serve as a postoperative analgesic.

8.30 a.m.

Anaesthesia was discontinued after changing the oral endotracheal tube for a nasal one in order to facilitate artificial ventilation in the ward. At this stage the systolic blood pressure was 95 mm.Hg, venous pressure 3 cm.H₂O and the oesophageal and rectal temperatures were both 34.2°C.

The volume of urine passed pre-bypass was 200 ml.

The volume of urine passed during bypass was 2,200 ml.

The volume of urine passed post-bypass was 820 ml.

The patient was returned to the ward and placed on a mechanical ventilator. The blood pressure was 100 mm.Hg at 8.45 a.m. Arterial pCO₂ was 28 mm.Hg and so the ventilation rate was adjusted from 20 to 16/min. Arterial pCO₂ then rose to 33 mm.Hg.

By 9 a.m. the following morning (4 December 1967) the patient had been weaned from the ventilator and placed in an oxygen tent, and at 10 a.m. the nasal endotracheal tube was removed.

DISCUSSION

As far as the transplant was concerned this was unknown territory, but in the management of the patient we were helped, of course, by previous experiences:

1. Cardiopulmonary bypass in this unit has been routine for many years and the teams are approaching their 1,000th bypass.

2. A successful renal transplant had been performed by the same team.
3. Some time previously a cardiac transplant was about to be undertaken; only the condition of the donor had prevented this from proceeding.

Thus, from the anaesthetic viewpoint, it was not anticipated that we would be faced with anything that we had not been faced with before, and the anaesthesia was conducted with optimism. In fact, things went very much as expected and we were not compelled to do anything of a startling nature. Inevitably, though, not everything went smoothly:

(a) This event occurred during a weekend and in the middle of the night and we found that the cylinders of CO₂/O₂ mixture which we use as the routine oxygenating gas were not available and so we had to use 100% oxygen in its place: this led to a marked respiratory alkalosis during the bypass period (Table I).

TABLE I. ARTERIAL ACID-BASE AND POTASSIUM DETERMINATIONS

	Blood samples						
	1	2	3	4	5	6	7
Time taken (a.m.)	2.23	2.47	3.33	4.29	5.31	6.00	7.13
Temp. oes. (°C)	35.2	25.5	22.3	21.1	29.0	36.1	34.1
rect. (°C)	35.6	33.7	24.4	27.7	24.0	31.0	34.0
Corr. pH	7.512	7.493	7.601	7.644	7.611	7.479	
Corr. pCO ₂ (mm. Hg)	26.5	25.0	16.5	16.0	21.1	26.7	27.0
B. base (m.Eq./l.)	43.9	39.3	42.9	42.5	45.4	43.3	44.0
B. excess (m.Eq./l.)	-1.3	-4.6	-2.2	-2.7	0.0	-3.0	-2.7
Std. HCO ₃ (m.Eq./l.)	22.8	20.1	22.1	21.6	23.9	21.5	21.7
K (mEq./l.)	5.7	5.5	4.6	4.7	4.6	5.1	3.1

(b) Lead I on the ECG was the only lead that did not show 60-cycle interference.

(c) The theatre X-ray unit failed to work and an end-of-operation chest radiograph could not be taken.

Comment on the Technique Used

1. *Induction of anaesthesia.* Every medical student knows that cardiac disease is a relative contraindication to the use of thiopentone. However, the enormous advantages of a smooth induction, and the knowledge that careful technique is—even in the cardiac patient—rarely followed by trouble, makes the use of thiopentone almost mandatory.

2. *Maintenance of anaesthesia.* For maintenance of anaesthesia during open heart operations there are many techniques. In spite of its reputation as a cardiac depressant, halothane in low concentrations has properties that are desirable; its concentration is easily regulated and some vasodilatation is desirable. Analgesic requirements in bypass anaesthesia are minimal.

3. *Post-bypass, during the retreat from surgery.* Halothane is no longer required and nitrous oxide and oxygen only are necessary.

SUMMARY

The conduct of anaesthesia for a patient undergoing cardiac transplantation is described.

The absence of references in this contribution should not be taken at face value. The arbitrary and random selection of some references would in no way reflect the enormous debt which we—and all other medical practitioners—owe to the experiences and thoughts of others.

I wish to thank Dr. Cecil Moss who assisted me during the operation, and Dr. J. G. Burger, Medical Superintendent of Groote Schuur Hospital, for permission to publish this report.