Anesthesia for cardiac transplantation

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The anesthetic care of the transplant patient requires the services of an experienced cardiac anesthesiologist for patients who have end-stage cardiac disease. Strict attention to detail and close observation and treatment of physiologic trends are required. This paper summarizes the special care required for these patients, any differences in the technique from the regular cardiac surgery patient, and the physiologic and pharmacologic responses of the denervated heart. Also, current statistics of the Stanford Cardiac Transplantation Program are presented.

At Stanford we have transplanted more than 200 hearts since January 1968. *Table 1* lists the primary diagnoses of 180 recipients. The two most common diagnoses are coronary artery disease and idiopathic cardiomyopathies. In *Figure 1* the survival rates of patients admitted to the Stanford Cardiac Transplantation Program, who had not yet undergone cardiac transplantation are plotted versus the survival rates of patients who had undergone transplantation. As a group, patients who do not undergo cardiac transplantation survive less than 6 months; patients who undergo transplantation currently have a 66% chance of surviving one year and a 50% chance of surviving 5 years.[1, 2]

Contraindications to cardiac transplantation in-

Table 1. Stanford cardiac transplantation

Primary diagnosis	No. of patients
Coronary artery disease	90
Idiopathic cardiomyopathy	79
Valve disease with myopathy	9
Posttraumatic aneurysm	1
Congenital heart disease	1
Total	180

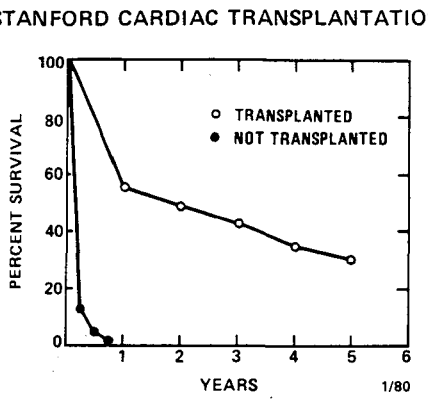

Fig. 1. Comparison of survival rates of patients who have undergone transplantation and those who have not.

clude patients older than 55 years, those with multiorgan failure at time of transplantation, active infection, insulin-dependent diabetes mellitus, pulmonary vascular resistance of more than 8 Wood units, and positive lymphocyte cross matching (cytotoxic effect of recipient serum against donor cells).

Figure 2 shows the actuarial survival statistics of the Stanford Cardiac Transplantation Program. Improvements in care have significantly increased the survival in the group operated on in the past 5 years. Most of this increase in actuarial survival is probably related to improvements in immunosuppressive therapy. Immunosuppression includes the drugs listed in *Table 2*. Chronic administration of immunosuppressive drugs is required with pulse therapy being administered to patients who show signs of acute rejection. One of the major improvements in care has been the routine use of endomyocardial biopsies for microscopic diagnosis of early rejection. These biopsies are done under local anesthesia through the right internal jugular vein.

Anesthetic care for these transplant recipients requires avoidance of drugs that can further depress the already severely compromised myocardium. It also requires a smooth induction technique with administration of appropriate chronotropic and inotropic drugs as necessary. Usually a high preload is required due to the severely depressed ventricular function curves and fixed

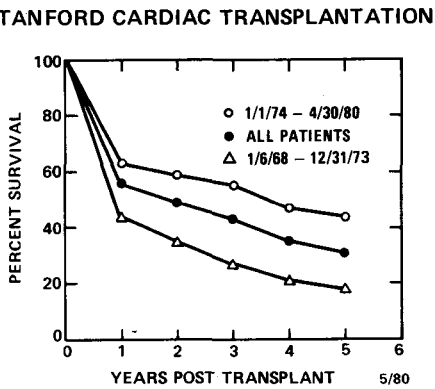

Fig. 2. Actuarial survival statistics showing increased survival in patients operated on in the past 5 years.

Table 2. Stanford cardiac transplantation

Immunosuppression drug regimen
Corticosteroids (prednisone)
Azathioprine
Antihuman thymocyte globulin (various species, e.g., rabbit, horse
? Cyclosporin A

stroke volumes. Often afterload reduction is beneficial in improving cardiac output in these patients. One center is beginning to place patients on intraaortic balloon pump support in the pretransplantation period,[3] although we have not made it a practice at Stanford because of the increased risk of infection.

The major difficulties in the anesthetic care for these patients develop from their depressed immune system and increased propensity to severe infection. *Table 3* lists the special requirements for these patients. Sterile technique must be used whenever the patient is contacted. Nasal intubation and urinary catheters are avoided because of the resulting bacteremia that can occur after these procedures. Unfortunately, we are unable to place pulmonary artery catheters because of the increased risk of infection, arrhythmias, and the fact that it would be necessary to remove the catheter when the heart is excised. Steroids are administered during surgery and most of these patients require chronotropic support (isoproterenol) in the postcardiopulmonary bypass period.

The denervated heart has been well studied in both animals and man.[4–6]

Table 3. Stanford cardiac transplantation

Special anesthetic care for the cardiac transplant recipient
Use sterile anesthesia breathing circle and airway management
All personnel use sterile technique
No nasal intubation
No urinary catheter (suprapubic, instead)
Keep right neck available for postoperative cardiac biopsies
No pulmonary artery catheter
Give steroids
Chronotropic support needed (isoproterenol) for the denervated heart

Table 4 summarizes the responses seen in the nonrejecting denervated heart. At rest normal intracardiac pressures are usually seen with a slightly decreased cardiac index. Since the recipient's SA node is intact there are two P waves seen on the electrocardiogram. Although reinnervation has been seen in animals, no human heart has been reinnervated. Therefore, the donor SA node is responsible for the pacing functions of the heart.

With exercise, normal hearts increase their cardiac index mainly by increasing their rate. The denervated heart, on the other hand, increases its cardiac index by the Frank-Starling effect of increasing its stroke volume. Changes in vagal tone have no effect on the heart. Therefore, there will be no change in heart rate with atropine, pancuronium, neostigmine, or edrophonium. Since the heart is still responsive to circulating catecholamines, there may be a slight increase of the heart rate during exercise, which can be blocked by beta-adrenergic blocking agents.

The coronary circulation responds in a normal fashion by decreasing its coronary vascular resistance in response to increased myocardial oxygen consumption occurring from increases in afterload, inotropy, and heart rate. In general, the nonrejecting denervated heart tends to be less inclined to ventricular arrhythmias with increased electrical stability of the ventricles. However, supraventricular arrhythmias are common because of the surgical trauma to the SA node.

The anesthetic care for patients who have previously received transplants who require surgery has been summarized.[7,8] These patients commonly present for surgery with various infections and steroid-related diseases. Sterility

Table 4. Denervated heart

At rest
Normal intracardiac pressures
Slightly decreased cardiac index
Donor and recipient P waves present
No reinnervation in humans
Exercise
Changes in vagal tone do not change heart rate
Cardiac index increases by changes in stroke volume mainly (Frank-Starling effect)
Heart rate increases only slightly (circulating catecholamines); this can be blocked by beta blockers
Coronary circulation
No differences from normals (e.g., decreased coronary vascular resistance from increased myocardial oxygen consumption and hypoxia)
Propensity to arrhythmias
More electrical stability of ventricles with less inclination for ventricular arrhythmias; increased tendency for supraventricular arrhythmias (sinus node dysfunction)

Table 5. Stanford cardiac transplantation

Primary cause of death	No. of patients
Infection	58
Acute rejection	22
Graft atheroslcerosis	13
Malignancy	6
Pulmonary hypertension	5
Cerebrovascular accident	3
Suicide	1
Total	108

during anesthetic care continues to be one of the prime concerns in these patients. If the patient is having subacute or acute rejection, various degrees of inotropic support may be necessary. *Table 5* shows the primary causes of death in a group of 108 cardiac transplant patients.

The most recent development in cardiac transplantation is the use of excised hearts from donors in distant areas.[9] The heart is excised, flushed with cold heparinized saline, and transported quickly to a waiting recipient. Obviously good communication and coordination are essential to the success of this operation.

Although cardiac transplantation is still in its infancy, it would appear that it is a reasonable alternate form of therapy for selected end-stage cardiac disease.

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