Heart transplantation

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Abstract

We review the contemporary management of end-stage heart disease with cardiac transplantation and the use of ventricular assist devices. When indicated, cardiac transplantation remains the gold standard therapy for end-stage heart disease. The outcome of transplantation is dependent upon the entirety of the transplantation process which consists of recipient factors, donor factors, organ retrieval, organ preservation, implantation and long-term management of transplant-related complications such as infection, rejection, malignancy and immunosuppression. However, despite best efforts a number of patients will die every year on the transplant waiting list. This is primarily due to a shortage of donors. In the recent years we have developed strategies to increase the number of organs, quality of donors and developed ways to support decompensated patients until a suitable organ has become available. The latter is known as bridging to transplantation. The most recent and promising development in this field has been in heart procurement. The traditional mode of preservation and transport of hearts on ice has been replaced by a sophisticated, device assisted organ care system (OCS). This probably reduces the ischaemic burden, permits longer cross-clamp times and may significantly increase the number of donor organs.

Keywords Heart; immunosuppression; surgical technique; transplantation

Indications for heart transplantation

Recipient criteria for heart transplantation include severe symptoms despite maximal medical management, the absence of reversible or surgically amenable heart failure, and where estimated 1-year survival is less than 50%.[1] An estimate of functional capacity can be quantified by measurement of peak O_2 consumption (VO_2max). Currently, VO_2max remains the single best cardiopulmonary evaluation to predict mortality in heart failure. Patients with low VO_2max (<12 ml/min/kg) have high mortality even if treated with beta blockers. The recent International Society of Heart and Lung (ISHLT) guidelines suggest that transplantation should be considered for these patients.[1] In addition, heart failure prognosis scores to estimate survival, such as the Heart Failure Severity Score, may be used. This calculates a survival probability on the basis of the presence of ischaemic cardiomyopathy, resting heart rate, left ventricular ejection fraction, mean blood pressure, interventricular conduction delay, VO_2max and serum sodium concentration.[2] Indications by aetiology are summarized in Box 1.

The eligibility for transplantation is considered with regard to several risk factors, notably pulmonary hypertension. Right heart catheterization should be performed in all potential candidates for heart transplantation to quantify pulmonary vascular resistance.[1] Patients with chronic heart failure may develop pulmonary hypertension due to elevated left ventricular end diastolic pressure with elevated left atrial and pulmonary venous pressures. This is a reactive form of pulmonary hypertension and may fall when the cardiac output is increased with inotropes or unloaded with nitrate infusions.[1] The Trans pulmonary gradient is calculated by subtracting the left atrial filling pressure (Wedge pressure) from the mean pulmonary artery pressure. A fixed transpulmonary gradient in excess of 14 mmHg is associated with greatly elevated risk, and thus this cut off is used in the UK. Other important risk factors are summarized in Box 2.

Preoperative preparation

Donor–recipient matching takes place on the basis of urgency, blood group and size (80% or greater of recipient body weight). With regard to HLA status, organs are not used when the recipient has pre-existing antibodies to the donor's HLA antigens. The donor heart is assessed by measurement of filling pressures and cardiac output with a Swan-Ganz pulmonary artery catheter inserted by the organ retrieval team or by direct pressure measurements. Trans-oesophageal echocardiography can be used to support the retrieval assessment process. Conditions precluding use of a donor heart are summarized in Box 3. If the donor heart is deemed to be satisfactory, the recipient is prepared for surgery. Induction Immunosuppression, typically with ciclosporin, is given preoperatively. Azathioprine and ciclosporin are given orally 2–4 hours preoperatively along with anaesthetic premedication.

Retrieval of donor heart

The retrieval process is a highly coordinated process as a part of multidisciplinary, multi-organ retrieval. On arrival to the donor hospital, the patient's clinical details and investigations are reviewed along with the donor coordinator. The functional and haemodynamic assessment of the heart is done by floating Swan-Ganz catheter. Increasingly, transoesophageal echocardiography is used to assess the function and to rule out valvular heart disease or congenital anomalies. After median sternotomy, the pericardium is opened the heart is inspected and palpated for size, contractility, regional wall motional abnormalities, thrills, myocardial contusion/damage and for any obvious congenital anomalies. The inferior vena cava (IVC), superior vena cava (SVC) and ascending aorta are dissected. Heparin, 30,000 units, is administered once the abdominal team is ready for organ perfusion and retrieval. The retrieval commences by venting the right and left heart to prevent distension and damage of ventricles, and by cross clamping the ascending aorta as high as possible. Cardioplegia solution (high concentration potassium solution with other preservatives) is administered via a cannula in the ascending aorta to effect diastolic arrest of the heart. The dose of cardioplegia is usually 10–15 ml/kg and conventionally

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Indications for heart transplantation

- Dilated cardiomyopathy
- Restrictive cardiomyopathy
- Ischaemic cardiomyopathy
- Valvular heart disease
- Congenital heart disease
- Re-transplantation

Box 1

Risk factors for heart transplantation

- Pulmonary hypertension
- Infection
- Irreversible liver, renal or pulmonary disease
- Age >60
- Diabetes/with severe end organ damage
- Cerebrovascular/peripheral vascular disease
- Malignancy
- Psychiatric disease
- Substance abuse
- Obesity

Box 2

Exclusion criteria for donor hearts

- HIV positivity
- Significant ventricular arrhythmias
- Echocardiographic abnormalities
- Significant global hypokinesia
- Significant valvular abnormality
- Significant coronary artery disease
- Any acute malignancy with the exclusion of primary brain cancer
- Inadequately treated systemic infection
- Hepatitis B surface antigen positivity, unless recipient is positive
- Significant left ventricular hypertrophy
- Cardiac contusion
- Death from carbon monoxide poisoning with carboxyhaemoglobin level >20%
- Intravenous drug abuse

Box 3

1 litre in majority of patients. The heart is cooled with topical ice-cold saline. The IVC is divided and an incision is made in the left atrial appendage if the lungs are concurrently retrieved to prevent distension of the LV. After completion of cardioplegia, the aorta is divided as high as possible. The pulmonary artery is divided at the level of its bifurcation. The SVC is divided at the level of the azygos vein. If the heart and lungs are to be retrieved, the left atrium is incised at the junction of the left superior pulmonary vein, and extended inferiorly. Care is taken to avoid injury to the coronary sinus. The incision continues inferiorly, and then to the junction of the right inferior pulmonary veins and left atrium. By this means the heart is excised with a cuff of left

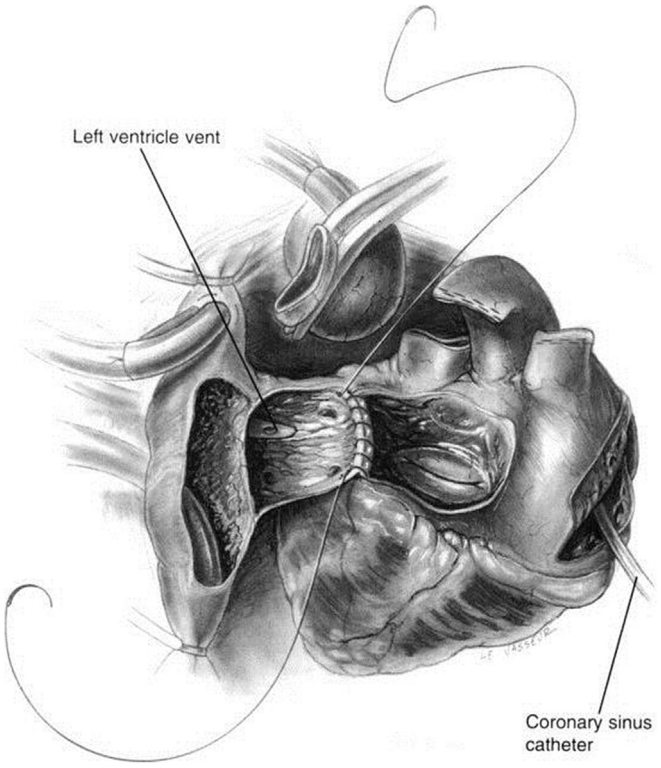

Figure 1 Commencement of the donor/recipient left atrial anastomosis. A coronary sinus catheter may be placed. (Reprinted with permission, Elsevier Limited.)

atrium and another adequate cuff of left atrium is left continuous with the pulmonary veins to facilitate lung retrieval and subsequent implantation. If the heart alone is to be retrieved, then the pulmonary veins are divided and the intact left atrium is left in continuity with the retrieved heart. Meticulous preservation of heart by administration of adequate cardioplegia and topical cooling is required. The retrieved heart is stored in ice-cold saline at 4°C, triple bagged and transported in ice to ensure myocardial protection. It is important to expeditiously transport the heart to the implant centre to ensure a tolerable ischaemic time. There is an inverse relationship between ischaemic time and post-transplant survival.[3] More innovative forms of procurement will be discussed later.

Recipient heart transplantation procedure

The timing of recipient surgery is very crucial to minimize the ischaemic time as short as possible. Hence, coordination is paramount. Under general anaesthesia, recipient sternotomy is performed and the diseased heart is exposed. Following full heparinization, cardiopulmonary bypass is accomplished with aortic cannulation, high in the ascending aorta and direct venous cannulation of the superior vena cava and inferior vena cava. In many situations, such as re-sternotomy with difficult mediastinal dissection and explantation of a left ventricular device (LVAD, see below) may need femoral cannulation for cardiopulmonary bypass.

Before the arrival of the donor heart in the operating room, the ascending aorta is cross-clamped and the diseased heart is excised. Explantation of heart is performed to facilitate the