Heart Transplantation in Adults with Congenital Heart Disease

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KEYWORDS

• Heart transplantation • Heart defects • Congenital • Heart failure • Patient selection

KEY POINTS

- Heart transplantation has become an increasingly common and effective therapy for adults with end-stage congenital heart disease (CHD) because of advances in patient selection and surgical technique.
- Indications for transplantation in CHD are largely similar to those for other forms of heart failure given the absence of specific guideline-based listing criteria.
- Pretransplant assessment of CHD patients emphasizes careful evaluation of cardiac anatomy, pulmonary vascular disease, allosensitization, hepatic dysfunction, and neuropsychiatric status.
- Cardiac transplant for CHD should be performed by surgeons experienced in congenital heart surgery given the complexities of CHD anatomy and the frequent need for adjunctive vascular reconstruction.
- Patients with a failed Fontan circulation have a higher posttransplant mortality than those with other CHD due to risk of infection, bleeding, and posttransplant right heart failure.

INTRODUCTION

Advances in medical and surgical inventions have led to remarkable improvements in the survival and quality of life of patients with CHD. The population of adults living with CHD is estimated to be increasing 5% per year and more than 85% of individuals born with CHD survive into adulthood.[1,2] Myocardial dysfunction in CHD can arise from prevailing hemodynamic insults from residual or uncorrected lesions or from previous palliative procedures that are now failing.[3] The burden of heart failure in patients with complex CHD will continue to increase as survivors of complex neonatal palliation from the 1980s and 1990s survive into adulthood. As a consequence, more adult CHD patients suffering from heart failure will merit consideration for cardiac transplantation as treatment of end-stage disease (**Box 1**).[4]

Historically, many transplant programs have been reluctant to offer transplantation to adults with CHD due to excess surgical risk related to multiple prior operations, recipient sensitization, and poor outcomes. Once deemed unacceptably risky or even ineffective, transplantation has become an increasingly common and effective therapy for adults with end-stage CHD because of advances in patient selection and surgical technique. Patients with CHD now account for 3% of adult heart transplants and more than 40% of heart-lung transplants in the United States.[5,6] Although an early hazard after transplantation for CHD remains, the intermediate-term and long-term survival rates for patients after transplant are similar to those transplanted for other causes of failure.[7,8] The continued improvement in outcomes after transplantation hinges on careful consideration of each patient's unique

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Box 1
Common forms of congenital heart disease leading to transplant in adulthood

Single-ventricle physiology

Fontan circulation

Congenitally corrected transposition of the great arteries

D-transposition after Mustard or Senning operation in which the systemic ventricle is the morphologic right ventricle

Tetralogy of Fallot with early-era surgery, long-standing shunt, or severe pulmonic regurgitation

Unoperated atrioventricular septal defects

Eisenmenger syndrome

anatomy and physiology. This review focuses on adults with CHD who have advanced heart failure and highlights the indications for transplant listing, elements of the transplant evaluation, operative considerations, and posttransplant outcomes.

INDICATIONS FOR TRANSPLANT

Although specific criteria for transplant in adults with CHD do not exist, indications for transplant are similar to those for non-CHD patients.[9,10] The most common reason for transplant is unremitting moderate-to-severe heart failure symptoms consistent with New York Heart Association (NYHA) class III-IV functional capacity despite optimal, guideline-based medical and device therapies (**Box 2**).[11,12] After the development of heart failure symptoms, palliative or corrective surgery for CHD is usually preferable to transplant listing. The possibility for surgical remediation should be reviewed by a congenital heart surgeon prior to transplant listing. Transplant is also appropriate in patients who are dependent on either continuous intravenous inotropes or a mechanical support device, because each of these treatments suggests a level of illness associated with a high mortality. Less commonly used indications for transplant include refractory ventricular tachycardia or angina not amenable to other therapies.

Exercise intolerance carries important prognostic significance in heart failure stemming from CHD.[13] Self-reported exercise tolerance in CHD is poorly correlated with objective measures of exercise capacity, so standardized testing is required.[14] Cardiopulmonary exercise testing (CPET) has become the single most important test for assessing appropriateness of transplant listing for all causes of end-stage heart failure. Transplant should never be based solely on CPET results; rather, CPET data should be thoughtfully integrated into the assessment of disease severity.[9] A maximal exercise test as assessed by a respiratory exchange ratio (RER) greater than 1.05 is required to determine if functional limitation is due to heart disease.[15] A reduced peak oxygen uptake is associated with a high mortality from heart failure and is the traditional CPET metric used for transplant listing.[16] Reduced peak oxygen uptake has been shown to predict hospital admission and death in CHD. It is not known whether the same threshold for listing should be used in CHD or if the thresholds are independent of the underlying congenital defect.[17]

In younger patients and in women, the peak oxygen uptake, which is indexed to body weight, can be misleading, so a less than 50% predicted uptake for age and gender can be used as an alternative transplant listing measure. For those patients who fail to reach maximal exercise (RER <1.05), the ventilation equivalent of carbon dioxide slope can be used to gauge cardiac limitations, with higher numbers reflecting more severe heart failure. This can be less useful in some forms of

Box 2
Indications for heart transplantation in adults with congenital heart disease

NYHA class III/IV symptoms from structural heart disease not amenable to correction or palliation

Cardiogenic shock requiring inotropes or an MCS device

Reduced functional capacity on CPET with maximal effort

- Peak oxygen uptake $\leq$12 mL/kg/min (or $\leq$14 mL/kg/min if intolerant to β-blockers)
- Peak oxygen uptake <50% predicted
- If submaximal effort (RER <1.05) a ventilation equivalent of carbon dioxide slope >35

Intractable life-threatening arrhythmias refractory to medical, ablative and device therapies

Intractable angina refractory to medical therapy or revascularization

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