



**FIGURE 11-4** Left image shows placement of the HeartWare ventricular assist device; right image demonstrates its relatively small size. See text for details. (Courtesy HeartWare Inc., Framingham, Mass.)

In both the CardioWest and the AbioCor TAH, morbidity and mortality are associated with significant risks of bleeding, infection, thromboembolism, and stroke. These complications are the target of current research for device improvement. Further studies are underway to assess the utility of the CardioWest TAH for destination therapy, and the AbioCor II is in development as a smaller and more durable device than the original.

### Cardiac Transplantation

During the last 2 decades, cardiac transplantation has become a life-saving treatment choice for patients with end-stage congestive heart failure. With advances in surgical techniques and immunosuppressive therapy, 1- and 5-year survival rates are about 90% and 75%, respectively. These rates are far superior to the 1-year survival rate for patients with advanced heart failure, which approaches 50%. Many patients who are eligible for cardiac transplantation die before surgery because of the limited number of donor hearts available each year. The development and widespread application of LVADs has allowed many of these patients who would otherwise die awaiting transplantation to survive until a donor heart becomes available. In many centers today, more than half of patients undergoing cardiac transplantation have previously undergone placement of a LVAD.

The major indications for cardiac transplantation are to prolong survival and improve quality of life. Determining which patients are suitable for cardiac transplantation can be difficult because many patients have clinical and hemodynamic improvement with intensification of medical therapy. In general, functional capacity, as assessed by exercise stress testing with measurement of maximal oxygen consumption at peak exercise, is the best predictor of whether a patient should be selected for cardiac transplantation. Individuals with severely impaired exercise capacity (e.g., peak oxygen consumption <10 to 12 mL/kg/min, with the lower limit of normal being 20 mL/kg/min) are most likely to experience a survival benefit from transplantation. Exclusion criteria include irreversible pulmonary vascular hypertension, malignancy, active infection, diabetes mellitus with end-organ damage, and advanced liver or kidney disease. Although

advanced age is associated with higher surgical and 1-year mortality rates, an age limit for cardiac transplantation is no longer strictly enforced at most centers, with patients instead being listed for transplantation based on an overall assessment of their physiologic status and potential for long-term survival after transplantation.

The procedure is performed through a median sternotomy incision. The posterior walls of the left and right atria with their venous connections are left in place and used to suture to the donor heart. The aorta and pulmonary artery are directly anastomosed to the recipient's great vessels. Immunosuppressive therapy is begun immediately after surgery and continued throughout the patient's life. Although new immunosuppressive agents are available, most regimens still include combinations of cyclosporine, azathioprine, and prednisone. Common complications during the first year include infection and rejection of the donor heart. In addition, hyperlipidemia and hypertension are common medical problems that may require treatment.

The major long-term complication is the development of coronary vasculopathy in the transplanted heart. In contrast to coronary artery atherosclerosis, which tends to be a focal process affecting primarily the proximal vessels, this disease is characterized by diffuse myointimal proliferation involving primarily the medial and distal segments of the coronary arteries. Although the cause of this disease is not entirely known, coronary vasculopathy is thought to be related to an immune-mediated response directed against the donor vessels. Monitoring for this complication can be difficult because angina is not provoked in the denervated heart and standard exercise stress testing has a low sensitivity for detecting this disease.

Coronary angiography is performed after transplantation and yearly thereafter to monitor for significant narrowing of the coronary arteries. However, the diffuse nature of the vasculopathy reduces the accuracy of coronary angiography for detection of this disease. Intracoronary ultrasound, with measurements of the intimal layer and coronary artery lumen size, is a new technique that appears to be more sensitive than coronary angiography for detection of this complication. Treatment options are limited,