MAYO CLINIC

REVIEW

Current Status of Left Ventricular Assist Device Therapy

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Abstract

Congestive heart failure (HF) remains a serious burden in the Western World. Despite advances in pharmacotherapy and resynchronization, many patients have progression to end-stage HF. These patients may be candidates for heart transplant or left ventricular assist device (LVAD) therapy. Heart transplants are limited by organ shortages and in some cases by patient comorbidities; therefore, LVAD therapy is emerging as a strategy of bridge to transplant or as a destination therapy in patients ineligible for transplant. Patients initially ineligible for a transplant may, in certain cases, become eligible for transplant after physiologic improvement with LVAD therapy, and a small number of patients with an LVAD may have sufficient recovery of myocardial function to allow device explantation. This clinically oriented review will describe (1) the most frequently used pump types and aspects of the continuous-flow physiology and (2) the clinical indications for and the shift toward the use of LVADs in less sick patients with HF. Additionally, we review complications of LVAD therapy and project future directions in this field. We referred to the Interagency Registry for Mechanically Assisted Circulatory Support, landmark trials, and results from recently published studies as major sources in obtaining recent outcomes, and we searched for related published literature via PubMed. This review focuses primarily on clinical practice for primary care physicians and non-HF cardiologists in the United States.

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Heart failure (HF) remains a major burden in terms of both morbidity and mortality in the United States and the Western World.[1,2] Although advances in pharmacological[3-5] and resynchronization device[6] therapy have led to reverse myocardial remodeling with symptomatic and survival benefit, many patients with HF have progression to end-stage disease. These patients have a poor quality of life with recurrent hospitalizations and a high mortality rate.[7] Therapeutic options for these patients include cardiac transplant or left ventricular assist device (LVAD) therapy. Although it remains the gold standard treatment for this population, cardiac transplant is limited by organ availability, fixed pulmonary vascular resistance due to prolonged advanced HF status, and other comorbidities in potential recipients.[8] In 2001, the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial found that LVAD therapy is superior to medical therapy in end-stage HF, with a 48% reduction in death from all causes.[9] Nevertheless, the most significant improvement was due to new technology with continuous-flow (CF) pumps.[10,11]

For patients with advanced HF, implantation of an LVAD has emerged as a bridge to transplant (BTT) or as destination therapy (DT) for those who are ineligible for transplant.[10,12] Left ventricular assist devices can be a bridge to decision for patients who are ineligible for transplant at the time of LVAD implantation but may become eligible after the procedure[13] and may also be utilized to promote myocardial recovery in a bridge to recovery strategy. Clinical trials have revealed the ability of the CF-LVAD to provide adequate support in both the BTT and DT settings,[14-18] and indeed, patients are reported to have been supported by the HeartMate (HM) II

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ARTICLE HIGHLIGHTS

- Left ventricular assist device (LVAD) therapy has become an accepted intervention for the treatment of late-stage heart failure because of the lack of organ donors.
- This review presents up-to-date information regarding indications, outcomes, complications, and future directions in the field of LVAD therapy.
- Left ventricular assist device therapy is commonly used as a bridge to heart transplant; however, the use of LVADs as a destination therapy is increasing, now providing long-term cardiac support.
- Early recognition of potential LVAD candidates and optimal timing of implantation improves clinical outcomes of LVAD therapy.
- A multidisciplinary approach is required to minimize complications of LVAD therapy.
- Future research should focus on the potential of LVAD therapy to promote cardiac recovery in selected populations.

(Thoratec Corporation), a CF-LVAD, for more than 5 years.[17] Excellent comprehensive guides for the management of patients with LVADs have been published previously.[19,20] This article reviews the use of LVAD therapy in these settings and explores future directions in this field.

LVAD PUMP TYPES: FROM PULSATILE- TO CONTINUOUS-FLOW DEVICES AND BACK TO ARTIFICIAL PULSATILITY

The LVAD systems consist of an inflow cannula placed in the apex of the heart, the pump itself, and an outflow conduit sutured to the aorta. A driveline is tunneled from the pump out of the body through an exit site to a belt controller and batteries. The HM II (Figure 1),[21] the successor to the pulsatile-flow (PF) HM XVE, provides CF via an axial propeller. The absence of a reservoir chamber and 1-way valves makes the device considerably smaller than the XVE,[22,23] allowing for use in a wider range of patients, including small adults and children.[14,23]

Other CF pumps utilize a magnetically levitating rotor system or hydrodynamic bearings to decrease mechanical wear, theoretically reducing hemolysis and the incidence of pump thrombosis. This group includes the HeartWare (HeartWare Inc) device (Figure 2),[24] a miniaturized centrifugal pump with a short inflow cannula that enables intrapericardial placement without pump pockets and abdominal operations that potentially can also be considered for right ventricular (RV) failure support as an off-label use. Studies have demonstrated successful utilization of this pump as a BTT strategy.[24-29]

Although a clear survival advantage with reliable CF pumps has been documented,[21] speculation has been raised regarding the physiologic impact of PF vs CF. Continuous-flow ventricular output negatively impacts nitric oxide production,[30] inflammatory biomarkers (ie, tumor necrosis factor α, C-reactive protein),[31] endothelial function,[31-33] and, in turn, organ microcirculation.[34,35] Animal models have revealed impaired gas exchange during CF.[36] The CF results in up-regulation of the renin-angiotensin system, and glomerular periarteritis has been noted with CF.[37] Newer generation pumps like, the HM 3 (Thoratec Corporation), a magnetically levitated CF-LVAD with artificial pulsatility, is being evaluated prospectively in the MOMENTUM 3 US IDE Clinical Trial for DT and BTT indications.[38] Thirty-day mortality was 2%, and 6-month survival was 92%, which exceeded the 88% performance goal.[29]

INDICATIONS, RISK FACTORS, AND EXCLUSION CRITERIA FOR LVAD THERAPY

Advanced HF is clinically defined as severe circulatory compromise requiring special care, including heart transplant (HTx), continuous inotropic therapy, mechanical cardiac support (MCS), or hospice care.[39] Patients who have refractory advanced HF symptoms despite optimal medical therapy may be considered for LVAD therapy, either as DT or as BTT. Patients listed for HTx are potential candidates for an LVAD as BTT. The placement of an LVAD may be required in those with severe symptomatic HF despite optimal medical therapy, especially if the patient's body size and blood type indicate that the wait for a possible donor organ will be prolonged. The large clinical trials for LVAD therapy include patients with New York Heart Association (NYHA) class IV symptoms, ie, substantially decreased exercise capacity due to cardiac limitation. The

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