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Extended Mechanical Circulatory Support With a Continuous-Flow Rotary Left Ventricular Assist Device

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Objectives This study sought to evaluate the use of a continuous-flow rotary left ventricular assist device (LVAD) as a bridge to heart transplantation.

Background LVAD therapy is an established treatment modality for patients with advanced heart failure. Pulsatile LVADs have limitations in design precluding their use for extended support. Continuous-flow rotary LVADs represent an innovative design with potential for small size and greater reliability by simplification of the pumping mechanism.

Methods In a prospective, multicenter study, 281 patients urgently listed (United Network of Organ Sharing status 1A or 1B) for heart transplantation underwent implantation of a continuous-flow LVAD. Survival and transplantation rates were assessed at 18 months. Patients were assessed for adverse events throughout the study and for quality of life, functional status, and organ function for 6 months.

Results Of 281 patients, 222 (79%) underwent transplantation, LVAD removal for cardiac recovery, or had ongoing LVAD support at 18-month follow-up. Actuarial survival on support was 72% (95% confidence interval: 65% to 79%) at 18 months. At 6 months, there were significant improvements in functional status and 6-min walk test (from 0% to 83% of patients in New York Heart Association functional class I or II and from 13% to 89% of patients completing a 6-min walk test) and in quality of life (mean values improved 41% with Minnesota Living With Heart Failure and 75% with Kansas City Cardiomyopathy questionnaires). Major adverse events included bleeding, stroke, right heart failure, and percutaneous lead infection. Pump thrombosis occurred in 4 patients.

Conclusions A continuous-flow LVAD provides effective hemodynamic support for at least 18 months in patients awaiting transplantation, with improved functional status and quality of life. (Thoratec HeartMate II Left Ventricular Assist System [LVAS] for Bridge to Cardiac Transplantation; NCT00121472) (J Am Coll Cardiol 2009;54:312–21)

Heart transplantation remains the most successful treatment option for patients with advanced heart failure refractory to medical therapy (1). As a consequence of limited donor availability (1), left ventricular assist device (LVAD) therapy has become an established treatment for patients with advanced heart failure as either a bridge to transplantation (BTT)

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(2) or as permanent support as an alternative to transplantation (3,4). Historically, patients have been supported by devices engineered with pulsatile design (i.e., HeartMate IP1000, VE, or XVE, Thoratec PVAD or IVAD, Thoratec Corporation, Pleasanton, California; or Novacor, World Heart Corporation, Oakland, California) (2,5–8). These devices are designed with an internal pumping chamber and inflow and outflow valves permitting cyclic filling and emptying with pump actuation elicited by either pneumatic or electrical systems (9). Previous studies have demonstrated the efficacy of these devices with regard to improvement in survival to transplantation (2) and improvement in survival compared with optimal medical management for patients with advanced heart failure, not candidates for transplantation (3).

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Pulsatile devices have limitations in their design that preclude their practical use for extended mechanical circulatory support (MCS). These limitations include a large pump size, requirement for extensive surgical dissection for implant, a large body habitus of the recipient, the presence of a large-diameter percutaneous lead for venting air, and audible pump operation (2,7). A critical limitation of the majority of these devices has been the high incidence of reoperation for device exchange for device infection or malfunction (3,10–12).

The REMATCH (Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure) trial demonstrated a survival advantage for LVAD therapy over optimal medical management for patients with advanced heart failure who were not eligible for transplantation. Although demonstrating the potential of MCS in providing improved survival, this trial demonstrated the risk of mechanical failure and device-related complications inherent in the pulsatile HeartMate VE LVAD (3,12). In patients surviving up to 2 years on device support, nearly 65% underwent replacement for infection or malfunction (12).

The development of continuous-flow rotary pump technology represents an innovative design for LVADs (13–18). These devices have the advantage of a smaller pump size and potential for greater mechanical reliability by simplification of the pumping mechanism (13,14). Reports from clinical trials of these newer pump designs have demonstrated efficacy in providing hemodynamic support and favorable risk-to-benefit ratio (15–18).

The HeartMate II LVAD is a continuous-flow rotary pump that has completed a U.S. Food and Drug Administration (FDA)-approved pivotal trial in 133 BTT patients (18). Since this report, 336 additional patients have undergone implantation of the HeartMate II LVAD as of April 2008 through a continued-access protocol approved by the FDA. We report on the first 281 patients entered into this clinical evaluation who have completed study end points or at least 18-month follow-up after LVAD implantation.

Abbreviations and Acronyms

BTT = bridge-to-transplantation
FDA = Food and Drug Administration
LVAD = left ventricular assist device
MCS = mechanical circulatory support
NYHA = New York Heart Association

Methods

Study design. Patients were enrolled in the study conducted at 33 centers in the U.S. between March 2005 and April 2008 (18). The study was supervised by the Thoratec Corporation. The clinical affairs and biostatistics departments at Thoratec designed the trial in consultation with the FDA and clinical investigators. Coordinators at each site collected study data, which was forwarded to the data analysis center of the sponsor. The academic authors vouch for the completeness and accuracy of the data and the analyses. A data and safety monitoring board, consisting of 4 independent physicians and 1 biostatistician who were not investigators in the study, met routinely to review study compliance, adverse events, quality of life, and outcomes of patients. These 5 committee members were compensated for their time, but none have any financial interest in the Thoratec Corporation or stand to gain financially from the outcome of the trial. A clinical events committee of 4 independent physicians who were not involved in the conduct of the trial reviewed, classified, and adjudicated the causes of death and all adverse events. The study was conducted in compliance with FDA regulations for Good Clinical Practices. The protocol was approved by the FDA and the institutional review board at each participating center.

Study subjects. Patients with heart failure who were on a waiting list for heart transplantation at each center were eligible for study enrollment. Patients were required to have symptoms of New York Heart Association (NYHA) functional class IV heart failure and to be ill enough to have high priority for transplantation (United Network for Organ Sharing status 1A or 1B). A complete list of study inclusion and exclusion criteria have been reported (18). All participating patients provided written informed consent before enrolling in the study.

Data collection baseline assessment. Baseline data were obtained upon patient consent and enrollment into the study. Information collected for baseline data have been previously reported (18).

Continuous-flow pump. The continuous-flow LVAD used in this study was the HeartMate II LVAS (Thoratec Corporation), which is a rotary pump with axial flow design (Fig. 1) (18). The system design and operating performance of the device have been previously described (18).

Surgical implantation. Surgical implantation of the HeartMate II LVAS was conducted according to the HeartMate II LVAS "Instructions for Use." Post-operative treatment included initiation of an anticoagulation regimen (18).