Impact of concurrent surgical valve procedures in patients receiving continuous-flow devices

Ranjit John, MD,[a] Yoshifumi Naka, MD,[b] Soon J. Park, MD,[c] Chittoor Sai-Sudhakar, MD,[d] Christopher Salerno, MD,[e] Kartik S. Sundareswaran, PhD,[f] David J. Farrar, PhD,[f] and Carmelo A. Milano, MD[g]

Background: Preexisting valve pathology is common in patients with end-stage heart failure undergoing left ventricular assist device (LVAD) placement. The indications and subsequent benefits of performing valvular procedures in these patients are unclear. The objective of this study was to determine the impact of performing concurrent surgical valve procedures in a large cohort of patients receiving LVADs.

Methods: One thousand one hundred six patients received the HeartMate II (HMII) LVAD in the bridge to transplant (n = 470) and destination therapy (n = 636) clinical trials. Of these, 374 patients (34%) had concurrent cardiac surgery procedures as follows: 242 patients (21%) with 281 concurrent valve procedures (VP) (aortic 80, mitral 45, and tricuspid 156), and 641 patients had only HMII LVAD. The focus of this study was to determine the clinical outcomes of patients undergoing HMII + VP compared with those who received HMII alone.

Results: Patients undergoing HMII + VP were significantly older, had higher blood urea nitrogen levels and central venous pressure, and decreased right ventricular stroke work index; intraoperatively, the median cardiopulmonary bypass times were also longer. The unadjusted 30-day mortality was significantly higher in patients undergoing HMII + VP (10.3% vs 4.8% for LVAD alone, $P = .005$). Subgroup analysis of individual VPs showed that higher mortality occurred in patients with HMII plus 2 or more VPs (13.5%, $P = .04$) followed by trends for increased mortality with HMII plus mitral alone (11.5%, $P =$ NS), HMII plus aortic alone (10.9%, $P =$ NS), and HMII plus tricuspid (8.9%, $P =$ NS) procedures. Of these various groups, only patients undergoing HMII + isolated aortic VP ($P = .001$) and HMII + multiple VPs ($P = .046$) had significantly worse long-term survival compared with patients undergoing HMII alone. Right heart failure and right ventricular assist device use was increased in patients undergoing VPs, but there was no difference in the incidence of bleeding or stroke.

Conclusions: Patients frequently require concurrent VPs at the time of LVAD placement; these patients are sicker and have higher early mortality. Furthermore, right ventricular dysfunction is increased in these patients. Further studies to develop selection criteria for concurrent valve interventions are important to further improve clinical outcomes. (J Thorac Cardiovasc Surg 2014;147:581-9)

The recent advent of continuous-flow left ventricular assist devices (LVADs) has had an important impact on survival and quality of life for patients once considered to have terminal heart failure.[1,2] An increasing number of patients with advanced stage heart failure refractory to medical therapy are being supported by LVADs as a bridge to heart transplant (BTT) or for destination therapy (DT). Support with an LVAD has become standard therapy in most advanced heart failure programs because of the increased acceptance of the therapy after positive clinical trial results.[3,4]

The US Food and Drug Administration commercially approved the HeartMate II (HMII) continuous-flow LVAD (Thoratec Corporation, Pleasanton, Calif) for BTT in 2008 and for DT in 2010.[1,2] Survival for the BTT indication has steadily improved since then and is approaching that of heart transplantation.[5] In 2010, outcome data from the postapproval study of commercial use conducted through the INTERMACS Registry showed a further increase in 1-year survival to 85% in the first group of patients.[6] Results for HMII LVAD as DT also continue to improve.[7]

It is well recognized that coexisting heart valve disease might complicate the placement and efficient functioning of LVADs. However, significantly abnormal valve

From the Cardiothoracic Surgery,[a] University of Minnesota, Minneapolis, Minn; Cardiothoracic Surgery,[b] Columbia Presbyterian Hospital, New York, NY; Cardiothoracic Surgery,[c] Mayo Clinic, Rochester, Minn; Cardiothoracic Surgery,[d] Ohio State University, Columbus, Ohio; Cardiac Surgery,[e] St Vincent's Heart Center, Indianapolis, Ind; Research and Scientific Affairs,[f] Thoratec Corporation, Pleasanton, Calif; Cardiothoracic Surgery,[g] Duke University, Durham, NC.

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Address for reprints: Ranjit John, MD, Division of Cardiothoracic Surgery, University of Minnesota, Minneapolis, MN 55455 (E-mail: johnx008@umn.edu).

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Abbreviations and Acronyms

AI = aortic insufficiency
BTT = bridge to heart transplant
BUN = blood urea nitrogen
CVP = central venous pressure
DT = destination therapy
HMII = HeartMate II
LV = left ventricular
LVAD = left ventricular assist device
RA = right atrial
RV = right ventricular
RVAD = right ventricular assist device
RVSWI = right ventricular stroke work index
TR = tricuspid regurgitation
VP = valve procedure

pathophysiology can also occur after LVAD placement and can seriously interfere with its benefits.[8] Native mitral and tricuspid valve disease is certainly more common in the patients with heart failure who are most likely to undergo LVAD placement. Nonetheless, aortic valves are much more likely to undergo structural changes and lead to abnormal pathophysiology in patients both during and after LVAD placement. The indications and subsequent benefits of performing valvular procedures in these patients are unclear.

The objective of this study was (1) to determine the impact of performing concurrent surgical valve procedures in a large cohort of patients receiving LVADs on short-term and long-term survival, and (2) postoperative morbidity in this patient population.

PATIENTS AND METHODS

Patients

This study is a retrospective review of 1106 patients supported by the HMII LVAD as BTT and DT during the clinical trial. Patients receiving the HMII as an exchange for a previous HeartMate XVE or as compassionate use were excluded from this analysis. The trial group included 470 patients undergoing BTT and 636 undergoing DT at 44 centers who were enrolled into the HMII clinical trial from March 2005 to January 2010. All patients met the study inclusion criteria and gave informed consent as approved by the Institutional Review Boards at the participating institutions.

Data Collection

For this study, the trial data were obtained from the study sponsor (Thoratec Corporation). The overall trial results have been published previously.[1,2,4]

End Points

The outcome end points analyzed in this study were overall survival from the LVAD implant, ongoing LVAD support, transplant, device removal after myocardial recovery, and death. Patients were divided into 2 groups: (1) patients who underwent HMII implantation alone without any concurrent procedures (HMII alone); and (2) patients who underwent concurrent valve procedures (HMII + VP). Adverse events occurring in these patients up to July 2012 were included (definitions are included in the supplementary material in Ref. 2), are also presented.

HMII LVAD

The pump used in this study was the HMII LVAD, which is a continuous-flow device consisting of an internal axial flow blood pump with a percutaneous lead that connects the pump to an external system driver and power source, which has been described previously.[3] The pump contains an internal rotor with helical blades that curve around a central shaft. When the rotor spins on its axis, kinetic energy is imparted to the blood, which is drawn continuously from the left ventricular (LV) apex through the pump and into the ascending aorta. The pump has an implant volume of 63 mL and generates up to 10 L/min of flow at a mean pressure of 100 mm Hg.

Surgical Implantation

Surgical implantation of the HMII LVAD was conducted according to the instructions for use of the HMII LVAD. The need for valvular procedures and the types and methods of valvular procedures used were at the investigator's discretion, and followed each centers' standard of care.

Postimplant Follow-up

After device implantation, a standardized antithrombotic medical regimen was implemented with initiation of heparin followed by transition to warfarin as well as aspirin. Postoperative medical management, including inotrope, antiarrhythmic, and heart failure therapy, was performed according to each investigator's preference and usual practice. Patients were followed up until July, 2012.

Statistical Analysis

All statistical comparisons were 2-sided. Data are given as the mean + standard deviation, or when appropriate, the median and range are provided. Discrete variables are given as a percentage. Differences in continuous variables between the study groups were determined with the *t* test or the nonparametric Mann-Whitney *U* test (when not normally distributed). The Fisher exact test was used to determine differences in categorical variables. Survival analysis was performed by using the Kaplan-Meier method with censoring for ongoing LVAD support in July, 2012, or device explantation for transplantation or recovery. Differences in survival were determined using the log-rank test. A multivariable risk factor analysis of death in this patient population was performed and published recently.[9] The analysis led to the development of the HMII risk score, which was validated in the same study for predicting 90-day mortality after HMII implantation. A Cox proportional hazards regression was performed to test the differences between patients with the HMII without any concurrent procedures, and (1) patients with the HMII who underwent a valvular procedure, (2) patients with the HMII who underwent an aortic procedure only, adjusted for the HMII risk score. Statistical analyses were performed using SAS software (SAS Institute Inc., Cary, NC).

RESULTS

Baseline Characteristics

There were a total of 1106 patients included in this study; 470 patients received the HMII LVAD as BTT and 636 patients as DT. Figure 1 shows the overall breakdown of patients investigated in this study. Of these, 641 patients had no concurrent procedures and 242 patients had