Management of Aortic Valve Insufficiency in Patients Supported By Long-Term Continuous Flow Left Ventricular Assist Devices

Jeffrey A. Morgan, MD, Robert J. Brewer, MD, Hassan W. Nemeh, MD, Scott E. Henry, MD, Narula Neha, BA, Celeste T. Williams, MD, David E. Lanfear, MD, Cristina Tita, MD, Gaetano Paone, MD

Divisions of Cardiothoracic Surgery and Cardiovascular Medicine, Heart and Vascular Institute, Henry Ford Hospital, Detroit, Michigan

Continuous flow (CF) left ventricular assist devices (LVADs) have yielded improved outcomes in patient survival and quality of life compared with first-generation pulsatile pumps; however, they have been associated with an increased incidence of postimplant aortic valve insufficiency (AI), which can have can have serious clinical consequences if not diagnosed and treated expeditiously. We reviewed our experience with AI after LVAD since the start of our CF LVAD program. From March 2006 through July 2011, 94 patients with chronic heart failure underwent implantation of a HeartMate II (HM II) LVAD. Severe AI developed in three patients after CF LVAD implantation. The clinical records of these patients were reviewed to analyze the presenting signs and symptoms of AI and to identify the duration of LVAD support when the AI occurred, how the AI was treated, and the outcomes.

Case Reports

Patient 1
A 54-year-old woman with ischemic cardiomyopathy, an ejection fraction (EF) of 15%, and end-stage heart failure refractory to medical management underwent implantation of a HeartMate II (HM II) LVAD as a bridge to transplant (BTT). There was no AI on the intraoperative transesophageal echocardiogram (TEE). Approximately 6 weeks after LVAD implantation, routine follow-up transthoracic echocardiography (TTE) revealed mild to moderate AI in an otherwise asymptomatic patient. The patient became symptomatic 5 months later with complaints of dyspnea, fatigue, and lower extremity edema. Repeated echocardiography demonstrated the AI to be moderate to severe (Fig 1). LVAD flows registered up to 8 L/min, but the cardiac index on right heart catheterization (RHC) was 1.9 and her renal function deteriorated, which is consistent with systemic malperfusion. An elevated panel reactive antibody (PRA) made timely transplantation unlikely; therefore, reoperation to address the AI was undertaken.

At reoperation, the aortic valve leaflets were found to be thickened and fibrosed with several areas of fusion. A single pledgeted 4-0 Prolene coaptation stitch was placed to close the central portion of the valve, as described by Park and colleagues [5]. TEE demonstrated no residual AI, and there has been no recurrence of AI on serial echocardiograms up to 2 years postoperatively.

Patient 2
A 57-year-old woman with a nonischemic dilated cardiomyopathy (NIDCM), an ejection fraction (EF) of 10%, and a previous mitral valve repair underwent implantation of a HeartMate II (HM II) LVAD as a BTT. There was no AI on the intraoperative transesophageal echocardiogram (TEE). Approximately 6 weeks after LVAD implantation, routine follow-up transthoracic echocardiography (TTE) revealed mild to moderate AI in an otherwise asymptomatic patient. The patient became symptomatic 5 months later with complaints of dyspnea, fatigue, and lower extremity edema. Repeated echocardiography demonstrated the AI to be moderate to severe (Fig 1). LVAD flows registered up to 8 L/min, but the cardiac index on right heart catheterization (RHC) was 1.9 and her renal function deteriorated, which is consistent with systemic malperfusion. An elevated panel reactive antibody (PRA) made timely transplantation unlikely; therefore, reoperation to address the AI was undertaken.

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medical therapy underwent implantation of an HM II LVAD as a BTT. There was no AI present at the time of implantation. Approximately 1 month postoperatively, a TTE demonstrated mild AI. Despite aggressive medical management with diuretics and afterload reduction, the amount of AI continued to worsen. At 3 months after LVAD, there was continuous regurgitation across the aortic valve in both systole and diastole, and the patient began experiencing recurrent signs and symptoms of heart failure. An RHC demonstrated a cardiac index of 1.4 despite a registered LVAD flow of 7.2 L/minute. Because of small body size and elevated PRA of 40%, prompt transplantation was unlikely, and the patient underwent reoperation for aortic valve repair. The aortic valve leaflets were fused, but unlike the previous case the leaflet tissue was significantly thinner and delicate. We began by placing a single pledgeted 4-0 Prolene coaptation stitch centrally, but we were concerned with the potential for tearing of the delicate valve leaflets. We then placed additional 4-0 Prolene pledgeted mattress stitches on each side of the central stitch between the central coaptation point and each of the three commissures for reinforcement and to reduce tension on the central stitch (Fig 2) [5]. There was no residual AI on postoperative TEE, and multiple echocardiograms up to 16 months after aortic valve repair have documented no recurrence of AI.

Patient 3
A 51-year-old man with NIDCM, and EF of 10% and end-stage heart failure refractory to medical therapy, underwent implantation of an HM II LVAD as a BTT. Approximately 3 months after VAD implantation, the patient began to exhibit recurrent heart failure symptoms. A TTE demonstrated moderate AI. LVAD flows registered 6.2 L/minute, but RHC showed a cardiac index of 2.2. He was managed medically with diuretics and afterload reduction with significant improvement of his symptoms, and he underwent successful heart transplant 9 months later.

Comment
Aortic insufficiency after implantation of a CF LVAD can have serious clinical consequences. The regurgitant blood flow creates a continuous nonfunctional flow loop that limits forward flow to the periphery. Despite abnormally high LVAD flow readings, often in the range of 7 to 10 L/minute, patients can be in cardiogenic shock because of inadequate end-organ perfusion.

The treatment of post-LVAD AI depends on the severity of the patient’s symptoms and transplant candidacy. For a patient with minimal symptoms, AI is initially treated with diuretics and afterload reduction. LVAD speed can be increased to provide additional flow through the device, which may translate into additional flow to the periphery if the AI does not worsen. However, this nonoperative treatment strategy is generally effective only for patients with mild AI. For patients who are candidates for heart transplantation, elevation to an urgent status on the waiting list may be the best option if they remain clinically stable and prompt transplantation is likely based on patient characteristics.

For patients with refractory symptoms, surgical intervention is indicated, and aortic valve repair is preferred over replacement. Aortic valve replacement is associated with longer cross clamp and bypass times and carries a risk of recurrence of AI, because the bioprosthetic valve leaflets can fuse in a similar manner to the native valve leaflets [8]. Repair of the aortic valve can be accomplished with partial closure of the leaflets with a central stitch, as described by Park and colleagues [5]. When the aortic valve leaflet tissue is thin and fragile, as was the concern in case two, we have modified this technique by placing an additional pledgeted mattress suture between the central stitch and each commissure. This modified technique more diffusely distributes the strength of the repair across the leaflets, as opposed to being provided exclusively by the central point of leaflet coaptation. Alternatively, the outflow tract can be excluded from the aorta by

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Fig 1. Echocardiogram demonstrating moderate-severe aortic insufficiency.

Fig 2. Modified central closure technique.
placing a circular patch over the valve leaflets, but a potential disadvantage of complete closure is that all systemic perfusion is dependent on device flow. Therefore, we prefer to use the modified central closure of the aortic valve as described above and thus far have not had problems with recurrent AI, although the experience is clearly limited. The degree to which these techniques will allow for ventricular ejection and adequate cardiac output in case of device malfunction is uncertain.

AI in the setting of a CF LVAD is likely caused by abnormal, constant stress on the aortic valve in the closed position. Because post-LVAD AI has been observed to worsen over time, we generally repair aortic valves with more than trivial (1+) AI at the time of LVAD implant. To date, we have performed a total of ten aortic valve procedures at the time of initial CF LVAD implantation. We initially performed bioprosthetic AV replacement in three patients, but have largely abandoned this for reasons discussed in this report. We then attempted central valve closure, but an early failure within 24 hours requiring reoperation and valve replacement led to further modification of our technique. We have now performed four modified central closures and one pericardial patch closure. None of the modified central repairs or replaced aortic valves have developed recurrent AI, but long-term follow-up with a larger group of patients is necessary to determine which surgical technique is superior. In addition, long-term data are necessary to evaluate the natural history of mild AI in LVAD patients to assist in more appropriate patient selection and data-driven indications for repairing the aortic valve at the time of the initial LVAD implant.

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References


Implantation of a HeartMate II Left Ventricular Assist Device via Left Thoracotomy

Yang Hyun Cho, MD, Salil V. Deo, MCh, John A. Schirger, MD, Naveen L. Pereira, MD, John M. Stulak, MD, and Soon J. Park, MD

Divisions of Cardiovascular Surgery and Cardiovascular Disease, Mayo Clinic, Rochester, Minnesota; Department of Thoracic and Cardiovascular Surgery, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea

Left thoracotomy was used as an approach for the implantation of pulsatile ventricular assist devices. Avoiding the standard approach of median sternotomy is attractive in patients undergoing complicated redo cardiac surgery, especially with prior mediastinal radiation. We report a case of the use of left thoracotomy for the implantation of the HeartMate II axial-flow pump.


The HeartMate II (Thoratec Corp, Pleasanton, CA) is an implantable left ventricular assist device (LVAD) approved by Food and Drug Administration (FDA) in the United States for life-long support. The standard approach for surgical implantation is through a median sternotomy. However, the operative risk associated with redo median sternotomy can be exceedingly high in some patients, especially those who had a prior complex cardiac surgery and mediastinal radiation [1, 2]. We approached such a patient via left thoracotomy and implanted the device successfully.

A 53-year-old man presented with recurrent congestive heart failure and NYHA class IV dyspnea. He had Hodgkin’s lymphoma treated with mediastinal radiation, resulting in radiation-induced heart disease. He had undergone coronary artery bypass surgery, mitral and tricuspid valve repair, and pericardiectomy 6 years earlier. He also had undergone surgical resection of the adenocarcinoma of the stomach 5 years ago. He developed progressive heart failure symptoms, and had required five hospital admissions over the past 8 months before being referred to our clinic. His left ventricular ejection fraction was 23%, and the left ventricular end-

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Address correspondence to Dr Park, Mayo Clinic, St. Mary’s Hospital, 2nd St SW GO-138SE, Rochester, MN 55902; e-mail: park.soon@mayo.edu.

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