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Readmissions After Implantation of Axial Flow Left Ventricular Assist Device

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Objectives The purpose of this study was to determine the occurrence and causes of readmissions after implantation of axial flow left ventricular assist device (LVAD).

Background Based on the REMATCH (Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure) study experience, readmissions after LVAD implantation are thought to be frequent.

Methods We retrospectively analyzed admissions to our facility in a cohort of 115 patients implanted between January 2008 and July 2011 with the HeartMate II axial flow LVAD, of whom 42 were bridged to transplant. To account for repeated events, Andersen-Gill models were used to determine possible predictors.

Results The patients were followed for 1.4 ± 0.9 years. There were 224 readmissions in 83 patients. The overall readmission rate was 1.64 ± 1.97 per patient-year of follow-up. The readmission rate for the first 6 months was 2.0 ± 2.3 and decreased to 1.2 ± 2.1 during subsequent follow-up. Leading causes were bleeding (66 readmissions in 34 patients), mostly gastrointestinal bleed (51 in 27 patients), cardiac (51 in 36 patients, most for HF or arrhythmia), infections (32 in 25 patients) of which 6 were pump related, and thrombosis (20 in 15 patients) including 13 readmissions due to hemolysis. Preoperative variables associated with (fewer) readmissions in a multivariate model include residence within our hospital-extended referral zone of Minnesota and the neighboring states (hazard ratio: 0.66; 95% confidence interval: 0.48 to 0.91; $p = 0.011$), hemoglobin (hazard ratio: 0.91, 95% confidence interval: 0.84 to 0.99; $p = 0.027$) and N-terminal pro–B-type natriuretic peptide (hazard ratio: 0.98; 95% confidence interval: 0.96 to 1.0 per 1,000-unit increase, $p = 0.022$). C-statistic for the model: 0.63.

Conclusions Readmission rates after axial flow LVAD implantation decrease during the first 6 months and then stabilize. The leading causes are bleeding, cardiac (heart failure and arrhythmia), infections, and thrombosis. (J Am Coll Cardiol 2013;61:153–63) © 2013 by the American College of Cardiology Foundation

Left ventricular assist device (LVAD) implantation has been shown to improve short-term (1 year) survival in stage D heart failure patients (1), and newer devices are providing improved durability for longer-term support (2). Thus, their use is increasing, specifically as destination therapy (DT) (3), and an increasing number of medical centers are involved in following patients supported with LVADs. The REMATCH (Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure) experience (1) suggested that readmissions after LVAD implantation are frequent. The long-term burden of recurring admissions to the implanting hospital in patients with the contemporarily used axial flow pumps may be of specific interest to medical centers involved with this approach to the treatment of end-stage heart failure.

Patients supported in the long term with axial flow devices generally feel better after device implantation as a result of improved hemodynamics and end-organ perfusion. However, caring for these patients may challenge the clinician with a unique set of medical problems. Previously described morbidities include gastrointestinal and cerebrovascular bleeding episodes, infections including those of the device and its driveline, thromboembolism including thrombus for-

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Abbreviations and Acronyms

CI = confidence interval
DT = destination therapy
HR = hazard ratio
LVAD = left ventricular assist device
NT-proBNP = N-terminal pro–B-type natriuretic peptide

mation on the pump, arrhythmias and right ventricular dysfunction. A comparative analysis of the major causes of readmissions after LVAD implantation may therefore be useful in providing perspective and categorizing the relative importance of morbidity associated with ongoing LVAD support.

The aim of this study was to determine the occurrence, causes, trends over time, and possible predictors of readmissions to the implanting hospital after LVAD implantation.

Methods

Patients. All patients surviving to discharge after implantation of a HeartMate II (Thoratec Corporation, Pleasanton California) LVAD at our institution between January 2008 and July 2011 were screened for readmissions.

We conducted a retrospective analysis of readmissions to our facility based on chart review. Baseline and follow-up characteristics of patients were retrieved from the electronic chart. The glomerular filtration rate was calculated based on the Modification of Diet in Renal Disease equation. Due to a general improvement during optimization before the operation, we differentiated baseline values (at the time of admission) from preoperative values (the morning before operation). Patients were censored for death, transplantation, or last follow-up. The study was approved by the Mayo Clinic institutional review board.

Evaluation and follow-up for LVAD patients at our facility includes comprehensive laboratory testing, cardiopulmonary exercise test and the 6-min walk test (for patients who can perform it), imaging (chest x-ray, abdominal ultrasound, carotid ultrasound, computed tomography when needed), electrocardiogram, echocardiogram as previously described (4), hemodynamic right heart catheterization and coronary angiography, renal function evaluation including iothalamate clearance, pulmonary function testing, fecal hemoglobin, and colonoscopy (unless performed within the previous 10 years). Specialty evaluation is also performed including assessment for the need for social services, rehabilitation, and palliative care. The data obtained on prospective candidates is then carefully reviewed and selection performed in a multidisciplinary conference. Preoperatively, patients are usually hospitalized for right heart catheterization, inotropic support, and intra-aortic balloon pump as needed.

Follow-up for LVAD recipients includes pre-scheduled outpatient visits and telephone follow-up. Visits are scheduled monthly for the first 3 months, every 3 months until 1 year, every 4 months in the second year, and every 6 months in the third and fourth years after implantation. Telephone assistance is available 24/7 by an LVAD coordinator for any patient-related questions or concerns with occasional coordinator-initiated follow-up calls. If a patient requires hospitalization, our usual preference is to recommend hospitalization at our facility. If the patient's medical situation does not allow that, we then recommend stabilization at a local medical facility with subsequent transfer. On arrival, patients are hospitalized, appropriate treatment initiated, and followed by the dedicated multidisciplinary LVAD service.

LVAD patients are treated with aspirin and warfarin with a goal international normalized ratio of 1.5 to 2.5, a proton pump inhibitor, and iron supplementation. If a major bleeding episode occurs, all anticoagulation is withheld for a month and then gradually resumed. An effort is made to identify the possible bleeding source (including upper and lower endoscopy, extended balloon endoscopy, and capsule enteroscopy in the case of gastrointestinal bleeding) and to treat it locally if possible. Lactate dehydrogenase is measured routinely during follow-up visits and an acute increase, when accompanied by symptoms, may prompt further evaluation for hemolysis due to pump thrombosis. Prophylactic antibiotic treatment is given before LVAD implantation and until 48 h after the operation. We do not use routine antibiotic prophylaxis thereafter unless otherwise indicated for endocarditis prophylaxis. Patients are instructed to meticulously clean the drive-line exit site daily.

Readmissions. We recorded all readmissions to our treatment facility until January 31, 2012. The date of admission, duration of stay, and primary reason for readmission was recorded. Primary diagnosis on discharge note was used to identify the cause for readmission. Causes were grouped based on mechanism into major groups including cardiac causes (arrhythmia, heart failure, chest pain), bleeding (any bleeding, anemia), infections (ventricular assist device–related and unrelated infections), thrombotic causes (thromboembolism, suspected LVAD thrombosis), LVAD related (abnormal readouts or alarms), biliary related (biliary colic, cholecystitis, biliary surgery, ductal cancer), elective readmissions (mostly for procedures), and other miscellaneous causes. Major neurological events were recorded as either thrombotic or bleeding events based on the presentation. Due to the morbidity related to such events, they are also reported separately in the results.

Rate calculation. Rate calculations were corrected for number of patients available and follow-up time normalized to derive yearly rates. We used the term readmission rate using readmission per patient-year units. The same was performed for length of stay to yield the term readmission duration rate using days per patient-year units. Monthly grouping (first 6 months) and 3-month grouping for later follow-up were performed.

Statistical analysis. Descriptive analysis was performed by presenting the mean ± SD for numerical data unless markedly non-normal, in which case the median and interquartile range (25th and 75th percentiles) were used