Ventricular Assist Device in Acute Myocardial Infarction

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ABSTRACT

BACKGROUND Patients with acute myocardial infarction (AMI) complicated by acute heart failure or cardiogenic shock have high mortality with conventional management.

OBJECTIVES This study evaluated outcomes of patients with AMI who received durable ventricular assist devices (VAD).

METHODS Patients in the INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) registry who underwent VAD placement in the setting of AMI were included and compared with patients who received VAD for non-AMI indications.

RESULTS VAD were implanted in 502 patients with AMI: 443 left ventricular assist devices; 33 biventricular assist devices; and 26 total artificial hearts. Median age was 58.3 years, and 77.1% were male. At implantation, 66% were INTERMACS profile 1. A higher proportion of AMI than non-AMI patients had pre-operative intra-aortic balloon pumps (57.6% vs. 25.3%; p < 0.01), intubation (58% vs. 8.3%; p < 0.01), extracorporeal membrane oxygenation (17.9% vs. 1.7%, p < 0.01), cardiac arrest (33.5% vs. 3.3%, p < 0.01), and higher-acuity INTERMACS profiles. At 1 month post-VAD, 91.8% of AMI patients were alive with ongoing device support, 7.2% had died on device, and 1% had been transplanted. At 1-year post-VAD, 52% of AMI patients were alive with ongoing device support, 25.7% had been transplanted, 1.6% had left VAD explanted for recovery, and 20.7% had died on device. The AMI group had higher unadjusted early phase hazard (hazard ratio [HR]: 1.24; p = 0.04) and reduced late-phase hazard of death (HR: 0.57; p = 0.04) than the non-AMI group did. After accounting for established risk factors, the AMI group no longer had higher early mortality hazard (HR: 0.89; p = 0.30), but it had lower late mortality hazard (HR: 0.55; p = 0.02).

CONCLUSIONS Patients with AMI who receive VAD have outcomes similar to other VAD populations, despite being more critically ill pre-implantation. VAD therapy is an effective strategy for patients with AMI and acute heart failure or shock in whom medical therapy is failing. (J Am Coll Cardiol 2016;67:1871–80) © 2016 by the American College of Cardiology Foundation.
Acutemycocardial infarction (AMI) is a common clinical problem with over a million cases annually in the United States alone (1). Improvements in management, particularly the paradigm of early revascularization, have improved the overall mortality after myocardial infarction (MI) to <5%. However, the most common cause of hospital mortality after MI, cardiogenic shock, complicates 8% to 12% of ST-segment elevation myocardial infarction and 5% of non-ST-segment elevation myocardial infarction and continues to have a high mortality of 40% to 50% (2,3). Most of these deaths are attributable to low cardiac output and end-organ dysfunction from left ventricular pump failure. Mechanical circulatory support has become an established therapy for end-stage chronic heart failure, but its role in shock or low-output states from AMI has not been well established. Patients with MI may not have sequelae of chronic heart failure, but may be more acutely ill, and the mode of deaths and complications in these patients after mechanical circulatory support (MCS) has not been evaluated in detail. The purpose of this study is to evaluate clinical characteristics and outcomes of patients who are supported with long-term ventricular assist devices (VAD) implanted in the setting of AMI.

**METHODS**

**DATA SOURCE.** The INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) database is a prospective national registry of Food and Drug Administration-approved durable mechanical circulatory support devices implanted in the United States. Patient enrollment started on June 23, 2006, and, as of December 2014, there were 156 participating sites and 14,214 enrolled patients. INTERMACS is the only registry that satisfies the Joint Commission’s requirement for a nationally audited registry for VAD and, until 2013, was the Center for Medicare Services-mandated registry for left ventricular assist device (LVAD) as destination therapy. Therefore, INTERMACS captures the vast majority of Food and Drug Administration-approved durable LVAD implants in the United States.

**STUDY GROUP.** All patients in the INTERMACS registry who received a durable continuous-flow LVAD with or without a right VAD, as well as patients who received a total artificial heart (TAH) were included in the study. Patients who had AMI as the admitting diagnosis or a major MI as a complication during hospitalization that resulted in VAD implantation (n = 502) were evaluated and compared with patients who underwent VAD implantation for non-AMI indications (n = 9,727).

**DATA COLLECTION.** Demographic, hemodynamic, severity of illness, and comorbidity data were collected at baseline. Routine follow-up data were collected at 1 week, 1 month, 3 months, 6 months, 12 months, 18 months, and every 6 months thereafter. Data on major adverse events was collected as the events occurred.

**DEFINITIONS.** The diagnosis of AMI was entered into the INTERMACS database on the basis of clinical and laboratory data at the implanting center. AMI was either the admitting diagnosis or a major complication during the hospitalization that resulted in VAD implantation. Adverse effects have been previously defined (4). The INTERMACS profiles 1 to 7 further characterize the severity of illness in advanced heart failure patients (5) (Online Table 1).

**FOLLOW-UP.** Follow-up for all study events was continued through March 31, 2014.

**STATISTICAL ANALYSIS.** Continuous variables were described with the median and interquartile range and compared using the nonparametric Mann-Whitney U test. Categorical variables were described with frequencies and compared using chi-square tests. Adverse event rates were calculated as events per 100 patient-months of follow-up and stratified as early (within 3 months of implantation) or late (>3 months post-implantation). Competing risk analysis was used to estimate the simultaneous time-related probabilities of patient outcomes. Parametric hazard modeling was used to evaluate the unadjusted and adjusted hazard ratios for early and late-phase mortality. The adjusted model contained risk factors identified in the 2014 INTERMACS annual report, including age, body mass index, mechanical ventilatory support, INTERMACS profile at the time of implantation, diabetes mellitus, dialysis at the time of implantation, creatinine level, right heart dysfunction, right VAD support, right atrial pressure, bilirubin, ascites, history of previous cardiac surgery, concomitant surgeries at the time of MCS, and destination therapy as implantation strategy (6). The INTERMACS Data Coordinating Center had access to primary data and performed all analyses. SAS
At 1 month post-VAD, 91.8% of AMI patients were alive with device in place, 7.2% had died on device, and 1% had been transplanted.

**RESULTS**

**BASELINE CHARACTERISTICS.** During the study period, 502 patients underwent VAD implantation in 105 hospitals in the setting of AMI, and 9,727 patients underwent VAD implantation in 143 hospitals for non-AMI indications. Patients with AMI were predominantly male, and the median age was 58.3 years. Patients with AMI were more likely to be current smokers, have previous cardiac surgeries, and have peripheral vascular disease than the non-AMI group was. They also had a shorter duration from first cardiac diagnosis to VAD implantation, and they had fewer previous cardiac surgeries and recent cardiovascular hospitalizations prior to VAD implantation (Table 1).

**ACUITY OF ILLNESS.** Patients with AMI undergoing VAD implantation were critically ill, with 66.7% being INTERMACS level 1 (“critical cardiogenic shock”) and 19.1% INTERMACS level 2 (“progressive decline”) at implantation (Table 2). Of all AMI patients, 94.8% had low output states requiring inotropes and/or temporary circulatory support (TCS). Laboratory and hemodynamic data are listed in Table 3.

Compared with non-AMI patients, AMI patients had more interventions in the 48 h prior to implantation (Table 2), higher acuity INTERMACS profiles, and a higher proportion that had cardiac arrest (33.5% vs. 3.3%; \( p < 0.0001 \)), intubation (58% vs. 8.3%; \( p < 0.01 \)), and dialysis (8% vs. 2.5%; \( p < 0.01 \)) during the hospitalization that led to VAD implantation.

**OPERATIVE CHARACTERISTICS.** The predominant device strategy was bridge-to-candidacy in the AMI group (53.8%). A higher proportion of patients underwent implantation of a biventricular assist device (BIVAD) (6.6% vs. 2.6%) or TAH (5.2% vs. 2.3%) in the AMI group compared with the non-AMI group. Patients in the AMI group had a higher proportion of concomitant coronary artery bypass graft (9.6% vs. 1.4%; \( p < 0.01 \)) and ventricular septal defect closure (0.8 vs. 0.2%; \( p < 0.01 \)), and a lower proportion of aortic valve repairs (1.2% vs. 2.9%, \( p = 0.02 \)), mitral valve repairs (1.6% vs. 3.6%; \( p = 0.02 \)), and tricuspid valve repairs (5.4% vs. 14.5%; \( p < 0.01 \)) than the non-AMI group did.

**OUTCOMES.** At 1 month post-VAD, 91.8% of AMI patients were alive with device in place, 7.2% had died on device, and 1% had been transplanted. At 1 year post-VAD, 52% of AMI patients were alive with ongoing VAD support, 25.7% had been transplanted, 1.6% had VAD explant for recovery, and 20.7% had died on device (Central Illustration).
Of AMI patients who were INTERMACS profile 1 at implantation, 89.8% were alive with VAD in place, 9% had died, and 1.2% had been transplanted by 1 month. At 1 year, the proportion of patients alive with ongoing VAD support, dead on a VAD, transplanted, and explanted were 52.2%, 22.05%, 24.05%, and 1.72%, respectively (Table 1).

Table 1: Laboratory and Hemodynamic Data

<table>
<thead>
<tr>
<th>Laboratory Parameter</th>
<th>AMI</th>
<th>Non-AMI</th>
<th>p Value</th>
</tr>
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<tbody>
<tr>
<td>Sodium, mEq/l</td>
<td>499</td>
<td>136 (133-139)</td>
<td>9,700</td>
</tr>
<tr>
<td>BUN, mg/dl</td>
<td>499</td>
<td>26 (18-38)</td>
<td>9,654</td>
</tr>
<tr>
<td>Creatinine, mg/dl</td>
<td>500</td>
<td>1.2 (0.90-1.65)</td>
<td>9,689</td>
</tr>
<tr>
<td>Alanine aminotransferase, U/l</td>
<td>468</td>
<td>51 (28-112)</td>
<td>8,883</td>
</tr>
<tr>
<td>Aspartate aminotransferase, U/l</td>
<td>464</td>
<td>53 (31-125.5)</td>
<td>8,865</td>
</tr>
<tr>
<td>Bilirubin, U/l</td>
<td>466</td>
<td>0.9 (0.60-1.40)</td>
<td>8,846</td>
</tr>
<tr>
<td>BNP, pg/ml</td>
<td>179</td>
<td>893 (443-1,560)</td>
<td>3,935</td>
</tr>
<tr>
<td>Pulmonary artery wedge pressure, mm Hg</td>
<td>184</td>
<td>25 (19-29)</td>
<td>5,351</td>
</tr>
<tr>
<td>RA pressure, mm Hg</td>
<td>267</td>
<td>12 (8-17)</td>
<td>5,990</td>
</tr>
<tr>
<td>Cardiac index, l/min/m², on inotrope/TCS</td>
<td>131</td>
<td>2.3 (1.8-2.8)</td>
<td>3,932</td>
</tr>
</tbody>
</table>

Values are n and median (IQR), and p values are determined on the basis of the Mann-Whitney U test. Categorical variables are reported as n (%) and p values are determined on the basis of the chi-square test.

AMI = acute myocardial infarction; BNP = B-type natriuretic peptide; BUN = blood urea nitrogen; IQR = interquartile range; RA = right atrial; TCS = temporary circulatory support.

Within the AMI group, patients undergoing TAH underwent higher rates of early transplantation. Of patients who initially underwent BIVAD, 52.4% were alive on VAD support at 1 year (Figure 2).

Overall outcomes for AMI and non-AMI patients were comparable (Central Illustration, Figure 4). Compared with the non-AMI group, the AMI group had a higher unadjusted early phase hazard of death (hazard ratio [HR]: 1.24; p = 0.04), and a reduced unadjusted late-phase hazard of death (HR: 0.57; p = 0.04). After accounting for established risk factors for mortality in a multivariate analysis using the risk factor model from the sixth INTERMACS annual report (6), the AMI group no longer had a higher early hazard for mortality (HR: 0.89, p = 0.30) but continued to have a lower late hazard for mortality (HR: 0.55; p = 0.02).

TEMPORARY CIRCULATORY SUPPORT. The use of TCS prior to VAD implantation for INTERMACS 1 to 3 patients confined to the hospital was evaluated. TCS, as defined for INTERMACS, includes any of intra-aortic balloon pump (IABP), ECMO, TandemHeart (CardiacAssist, Pittsburgh, Pennsylvania), Levitronix (Levitronix Technologies, Framingham, Massachusetts), Abiomed BVS 5000 or AB5000 (ABIOMED, Danvers, Massachusetts), and Impella (ABIOMED). Patients with AMI had higher use of TCS than the non-AMI group for each of the 3 INTERMACS profiles (65% vs. 51% for INTERMACS profile 1; 43% vs. 19% for INTERMACS profile 2; and 49% vs. 8% for INTERMACS profile 3; p < 0.01). A substantially higher proportion of AMI patients had IABP (57.6% vs. 25.3%; p < 0.01) and ECMO (17.9% vs. 1.7%; p < 0.01) than the non-AMI patients did. At 1 year, there was no difference in the proportion of patients alive on device, dead, transplanted, or explanted between the AMI INTERMACS 1 to 3 patients who received pre-operative TCS versus those who did not receive TCS (p = 0.30) (Online Figure 2).

ADVERSE EVENTS. Compared with the non-AMI group, the AMI group had higher early rates for bleeding, arrhythmia, infection, neurological dysfunction, renal dysfunction, thromboembolism, and respiratory failure; a lower early rate for
rehospitalization; and a lower late rate for right heart failure and cardiac arrhythmias (Table 4).

DISCUSSION

Advances in the management of MI have improved overall outcomes, but patients who progress to cardiogenic shock continue to have a high mortality. Early revascularization has been the primary acute treatment for MI. However, revascularization alone cannot reverse a completed infarction and may result in additional reperfusion injury. Furthermore, revascularization does not immediately offload the injured ventricle or reverse systemic dysfunction in multi-organ failure. Alternative strategies are therefore necessary to improve outcomes of patients who have persistent shock despite revascularization and medical therapy.

Observational reports have suggested significant hemodynamic and clinical benefit of MCS in cardiogenic shock-complicating acute myocardial infarction (AMI-CS), but no randomized trial has
demonstrated a survival benefit (7). Most of the randomized studies were designed to study hemodynamic improvements and were underpowered to assess survival. The only major recent randomized controlled trial of mechanical support in AMI-CS, the IABP SHOCK II (Intraaortic Balloon Pump in Cardiogenic Shock II) trial, showed that IABP did not improve survival (8). Given the lack of well-defined criteria for VAD insertion and a weak recommendation for MCS in the guidelines used in the trial (9), VAD insertion was discretionary and not an integral part of the IABP-SHOCK II protocol for patients with persistent shock on IABP. Only 5.5% underwent VAD placement, with a high mortality of 69.7%.

This analysis of a comprehensive nationwide VAD registry demonstrates that patients who undergo durable VAD implantation in the setting of MI can have good outcomes despite high clinical acuity at the time of VAD implantation. The majority of patients with MI receiving VAD were INTERMACS profile 1, and 95% had a low output state requiring inotropes or TCS (INTERMACS profiles 1 through 3). These critically ill patients had 1-month survival on device ≥90% and overall outcomes comparable to other populations on VAD support, who were generally less ill at the time of VAD implantation. AMI patients underwent VAD implantation at over 100 centers, providing reassurance of the reproducibility of the results.

It is important to note that INTERMACS is designed to focus on patients who receive durable VAD. It does not collect data on all patients with MI and shock, such as those who recovered with standard therapy without requiring VAD or who died of progressive shock despite medical therapy ± TCS without receiving durable VAD. Therefore, this study does not directly test the hypothesis that VADs improve outcomes of patients with AMI-CS compared with conventional (i.e., non-VAD) therapy. Instead, this

Competing outcomes curves for patients with acute myocardial infarction (AMI) undergoing left ventricular assist device placement, stratified by age (<55 years: n = 187; 55 to 65: n = 206; >65: n = 109). Older patients had lower overall survival than did younger patients. However, 1-month survival was similar among the 3 groups and survival differences were more prominent starting 3 months after left ventricular assist device implantation.
analysis quantifies short- and long-term outcomes of patients who are selected for long-term support with durable VAD in the setting of acute MI, taking into consideration their baseline clinical characteristics and severity of illness, and shows that early durable VAD is a feasible and effective long-term management approach for patients with AMI-CS who have not responded to standard therapy. Clinical trials comparing strategies of management of cardiogenic shock, with particular attention to the timing of temporary and durable MCS and escalation guided by hemodynamics, perfusion, and end-organ function, are urgently needed to provide more definitive evidence of the magnitude of survival benefit, to provide further guidance in appropriate candidate selection and optimization, and to refine the indications and thresholds for VAD therapy in this patient population.

Early unloading of the infarcted myocardium and hemodynamic support with Impella or ECMO has been shown to improve overall outcomes in patients with AMI-CS in observational studies (10,11). Similarly, in patients who have refractory shock and are potential LVAD candidates, stabilization of end-organ function and correction of metabolic derangements with ECMO prior to durable LVAD implantation can improve post-LVAD survival (12,13). This strategy can be attractive because TCS is less invasive and resource-intensive than durable LVAD, stabilization by TCS allows time for a more detailed assessment of LVAD/transplant candidacy, and patients who do not survive or stabilize with an adequate support TCS device, such as ECMO, are unlikely to have benefitted from LVAD (13). In this study, AMI patients had higher rates of TCS use, which may have stabilized end-organ and right ventricular function, therefore positively influencing post-LVAD survival. AMI patients who were stabilized with TCS had similar post-LVAD outcomes as patients who did not require TCS. These findings highlight the importance of early detection of cardiogenic shock and prompt goal-directed

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**FIGURE 3  Outcomes by Device Type**

Competing Outcomes - AMI - LVAD
Primary Prospective Implants: June 23, 2006 to March 31, 2014

Competing Outcomes - AMI - BIVAD
Primary Prospective Implants: June 23, 2006 to March 31, 2014

Competing Outcomes - AMI - TAH
Primary Prospective Implants: June 23, 2006 to March 31, 2014

Competing outcomes of patients with myocardial infarction receiving left ventricular assist device (LVAD) (n = 443), biventricular assist device (BIVAD) (n = 33), or total artificial heart (TAH) (n = 26). Patients with TAH had high rates of early transplantation. AMI = acute myocardial infarction.
therapy with revascularization, and pharmacological and temporary support to limit myocardial injury, ensure adequate perfusion, and prevent or reverse end-organ failure. It is also crucial to assess candidacy for LVAD or transplant early in the process to allow adequate evaluation of social, neuropsychological, and other medical comorbidities that may affect post-LVAD outcomes and likelihood of subsequent transplantation, and to allow the opportunity to provide a more informed consent for this life-saving, but highly invasive, resource-intensive, and lifestyle-altering therapy.

Early complications in the MI group were dominated by infection, respiratory failure, neurological dysfunction, and renal failure. Late complications were those commonly seen in LVAD populations, with a steady annual mortality rate of 7% to 9%. In comparison, patients with shock who survived the first year in the GUSTO (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) I trial had an annualized 2% to 4% mortality, and those in the revascularization arm who survived the initial hospitalization in the SHOCK (Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock) trial had a 6-year survival of 62.4%, with an annual mortality rate of 8% (14–16). Therefore, LVAD therapy can rescue patients with AMI and shock and provide favorable early to mid-term survival, but VAD-related complications are common and long-term survival depends on appropriate VAD management, improvements in VAD technology, and consideration for transplantation for those who are candidates.

In this study, competing outcomes analysis was used to examine mutually exclusive events, such as survival on device, transplant, death, or explantation. The conventional Kaplan-Meier method, which examines only 1 event at a time, while censoring for other events, provides only partial information on all possible outcomes of interest and may not be valid when the censoring is informative. For example, a patient with a VAD complication may be listed at a higher priority for transplantation and may get transplanted earlier. Censoring at transplantation would, in this case, be informative because that patient’s prognosis may not have been the same as

<table>
<thead>
<tr>
<th>Table 4 Adverse Events</th>
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<tbody>
<tr>
<td><strong>Early Period</strong></td>
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<tr>
<td><strong>AMI Rate</strong></td>
</tr>
<tr>
<td>(n = 502) (Per 100 Patient-Months)</td>
</tr>
<tr>
<td>Bleeding</td>
</tr>
<tr>
<td>Cardiac arrhythmia</td>
</tr>
<tr>
<td>Hemolysis</td>
</tr>
<tr>
<td>Infection</td>
</tr>
<tr>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>Neurological dysfunction</td>
</tr>
<tr>
<td>Other SAE</td>
</tr>
<tr>
<td>Rehospitalization</td>
</tr>
<tr>
<td>Renal dysfunction</td>
</tr>
<tr>
<td>Respiratory failure</td>
</tr>
<tr>
<td>Right heart failure</td>
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<tr>
<td>Venous thromboembolism</td>
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AMI = acute myocardial infarction; SAE = serious adverse events.

FIGURE 4 Competing Outcomes in Non-AMI Patients

Competing outcomes of patients undergoing left ventricular assist device placement for non-acute myocardial infarction (AMI) indications (n = 9,727).
that of other patients who remained on VAD support. In this situation, competing outcomes analysis can provide simultaneous time-related probabilities of different competing events of clinical interest and highlights several important findings in patients with MI undergoing VAD, as outlined in the subsequent discussion.

The highest risk of death occurred within the first 3 months after LVAD implantation, likely reflecting the pre-operative clinical acuity, after which time, the risk of death decreased and remained relatively stable. The majority of transplants occurred between 3 and 15 months after LVAD implantation. Patients who were not transplanted by that time had a relatively low rate of subsequent transplantation, likely related to comorbidities, VAD complications, and age. Only a small minority of patients (1.6%) with AMI-CS who required durable VAD had adequate recovery for explantation, and almost all explants occurred within the first year after LVAD placement. This finding is consistent with another report showing that patients with severe shock from MI have low rates of ventricular recovery, despite revascularization (17). BIVAD or TAH were both viable options for patients with biventricular failure. Most patients (79.8%) with TAH were transplanted within the first year, whereas over one-half of the patients initially receiving BIVAD were alive on device at 1 year post-implantation. Advantages of BIVAD over TAH may include the potential for right VAD explantation and implantation. The registry only includes patients who were selected to receive durable LVAD support if there is right ventricular recovery, whereas TAH may be particularly suited for post-infarction shock and unrepairable ventricular septal defects.

Compared with non-AMI patients, patients with VAD post-AMI had a significantly lower adjusted late hazard for mortality. This was not related to advantages in age, sex, renal function, liver function, or lower burden of cardiac risk factors. However, patients in the AMI group had fewer previous cardiac operations, fewer cardiovascular hospitalizations, and a shorter duration of cardiovascular symptoms. The lower pre-existing cardiovascular burden and the absence of long-term effects of heart failure, such as cardiac cachexia and right heart failure, may have accounted for some of the differences in mortality. These findings corroborate a recent study that showed that shorter duration of heart failure at LVAD implantation mitigates some of the risks of high acuity (18).

Patients presenting with MI and shock are a heterogeneous population, and the management approach needs to be individualized. A patient with first MI and mild-moderate shock may recover with revascularization and medical therapy alone, whereas a patient with pre-existing ischemic cardiomyopathy and vein graft occlusion causing AMI-CS would be less likely to recover, even with revascularization and TCS, and more likely to require durable LVAD. A patient with mild shock may be supported with inotropes or low-support TCS device (e.g., IABP/Impella 2.5); however, these devices only provide short-term support, do not provide adequate hemodynamic support for all degrees of shock, and therefore would not be definitive therapy in patients with severe shock. Early outcomes may be improved by optimizing hemodynamics and perfusion with MCS and vasoactive agents. However, once there is a systemic inflammatory state and multisystem organ failure, even full mechanical support and normalization of cardiac output may not improve survival, which is no longer mediated by hypoperfusion alone (19,20).

Further studies are therefore needed to address several questions, including the ideal timing of MCS, the role of TCS, and identification of patients who do not derive benefits from MCS.

**STUDY LIMITATIONS.** First, the registry only includes patients who were selected to receive durable MCS at the discretion of the medical team. Although the clinical acuity was very high, patients were generally relatively young, with only modest degrees of renal and hepatic dysfunction. Patients with established irreversible multisystem failure despite inotropes and/or TCS, very advanced age, or significant frailty who were not expected to survive operations for LVAD were probably not offered LVAD support. Second, only the data collected per registry protocol was available. The diagnosis of AMI was coded at each implanting center, rather than being centrally adjudicated. Several variables, such as location of infarct, magnitude of troponin elevation, details regarding percutaneous coronary intervention and success of revascularization, and time between onset of shock and VAD implantation are not available. Third, patients were followed only during the period during which they had a durable LVAD. Detailed data regarding degree of stabilization by TCS prior to LVAD implantation, waiting time for transplantation, or outcomes of patients after transplantation are not available. This is one of the major limitations in the current state of knowledge about AMI-CS. Registries, such as the ACC-NCDR (American College of Cardiology-National Cardiovascular Data Registry) databases, INTERMACS, and UNOS/SRTR (United Network for Organ Sharing/Scientific Registry of Transplant Recipients), that evaluate patients at certain stages of management
are not effectively linked, and there is no large multicenter registry or trial that systematically evaluates the whole spectrum of patients from initial presentation to ultimate therapy. Finally, patients were not randomized, there was no matched medical therapy group, and we were unable to directly evaluate the magnitude of survival benefit conferred by MCS. Nevertheless, multiple contemporary studies in comparable populations have shown high mortality with conventional therapy, and this real-world multicenter experience shows that durable VAD therapy can result in favorable outcomes in the setting of acute MI.

CONCLUSIONS

Durable VAD implantation is an effective management strategy and should be considered early for patients with myocardial infarction and low output states who do not respond to medical therapy.

REFERENCES


APPENDIX

For supplemental tables and figures, please see the online version of this article.