Bridge to durable left ventricular assist device for refractory cardiogenic shock

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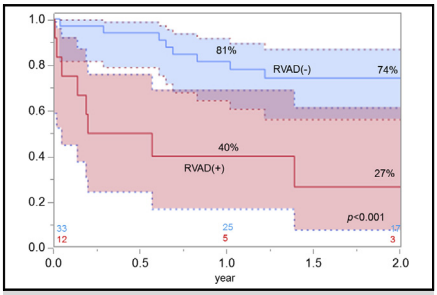
ABSTRACT

Objective: The role of short-term mechanical circulatory support has increased in patients with refractory cardiogenic shock. However, limited data exist on the outcomes of a bridge to a durable left ventricular assist device strategy using short-term mechanical circulatory support.

Methods: We retrospectively reviewed 382 patients who underwent continuous-flow left ventricular assist device insertion between 2004 and 2014. Of these, 45 (12%) were bridged with short-term mechanical circulatory support devices for refractory cardiogenic shock. We analyzed early and midterm outcomes in this bridged cohort. Multivariate Cox proportional hazards modeling was performed to evaluate the predictor of overall death in the entire cohort.

Results: The mean age of the bridged cohort was 53 ± 10 years, and 87% were male. The types of initial support included percutaneous devices in 24 patients (53%) and external continuous-flow ventricular assist device in 21 patients (47%). The median duration of short-term mechanical circulatory support was 14.0 (interquartile range, 7.5-29.5) days. The short-term mechanical circulatory support significantly improved end-organ function and hemodynamics. After conversion to durable left ventricular assist device insertion, in-hospital mortality was 18%. The incidence of right ventricular assist device use was high at 27%. The overall survival was 70% and 62% at 1 and 2 years, respectively. Cox multivariate hazard analysis in the entire cohort demonstrated that the use of a postoperative right ventricular assist device was a significant predictor of overall death (hazard ratio, 4.04; $P < .001$; 95% confidence interval, 1.97-7.94), but the use of a short-term mechanical circulatory support was not ($P = .937$).

Conclusions: Short-term mechanical circulatory support can optimize patients in refractory cardiogenic shock and serve as a bridge to implantation of a durable left ventricular assist device. However, the early mortality rate after durable left ventricular assist device implantation is high because of unrecognized right ventricular failure. (J Thorac Cardiovasc Surg 2016;■:1-11)



Short-term mechanical circulatory support can serve a bridge to durable LVAD therapy.

Central Message

ST-MCS can optimize patients in refractory cardiogenic shock and serve as a bridge to durable LVAD. However, the early mortality rate after durable LVAD implantation is high because of unrecognized right ventricular failure.

Perspective

No established guidelines exist on the approach before durable LVAD implantation for patients in refractory cardiogenic shock. This study shows the usefulness of ST-MCS as BTB therapy for patients in refractory cardiogenic shock at a single high-volume center. The results will allow better strategy in selection and treatment for patients in cardiogenic shock.

MCS

Left ventricular assist devices (LVADs) have become the standard of care for patients with end-stage heart failure as a bridge to transplant therapy and as a destination

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Abbreviations and Acronyms

BTB = bridge-to-bridge
ECMO = extracorporeal membrane oxygenation
HMRS = HeartMate II Risk Score
INR = international normalized ratio
INTERMACS = Interagency Registry for Mechanically Assisted Circulatory Support
LV = left ventricular
LVAD = left ventricular assist device
MELD = Model for End-Stage Liver Disease
RVAD = right ventricular assist device
ST-MCS = short-term mechanical circulatory support

therapy.[1-3] The 7th annual Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) report stated that approximately 15% of all patients underwent LVAD implantation in an INTERMACS profile I; this rate has not changed in the past several years.[4] Despite improving overall outcomes, worse outcomes of patients with an INTERMACS profile I have been reported compared with those of patients with other profiles.[4]

The major problems of patients with refractory cardiogenic shock and an INTERMACS profile I include not only collapsed hemodynamics but also other end-organ dysfunction or uncertified neurologic status. At the first encounter with patients in cardiogenic shock, the candidacy for destination therapy or bridge-to-transplant LVAD often is unclear. In addition, because of the acuity of the illness, the time available to make a decision is limited. Therefore, an alternative approach instead of primary implantable LVAD insertion can be considered using short-term mechanical circulatory support (ST-MCS) for patients with refractory cardiogenic shock. This treatment strategy is considered bridge-to-bridge (BTB) therapy.[5-7] The advantage of this strategy is that hemodynamic stability and end-organ function improvement can be achieved before long-term durable LVAD implantation.[5] However, little data exist on the outcomes of the bridge to durable LVAD strategy in the population receiving BTB therapy. The purpose of this study was to elucidate the short- and midterm outcomes in patients receiving BTB therapy.

MATERIALS AND METHODS

Patient Selection

The Columbia University Medical Center Institutional Review Board approved this study. A total of 382 patients who received continuous-flow LVADs between March 2004 and December 2014 at the Columbia University Medical Center were retrospectively reviewed. Of these patients, 45 (12%) received ST-MCS for refractory cardiogenic shock before undergoing durable LVAD implantation surgery (BTB group). We analyzed the clinical results of these 45 patients.

Strategy for Patients in Refractory Cardiogenic Shock

Our strategy for patients in refractory cardiogenic shock is shown in Figure E1. In general, all patients in refractory cardiogenic shock received ST-MCS devices to stabilize and optimize their condition during this study period. Refractory cardiogenic shock is characterized by a systolic blood pressure less than 90 mm Hg, cardiac index less than 2.0 L/min/m^2, pulmonary capillary wedge pressure greater than 16 mm Hg on adequate inotropes (or evidence of pulmonary edema in the absence of a pulmonary artery catheter), and evidence of end-organ failure or the inability to be weaned from cardiopulmonary bypass for postcardiotomy shock. These patients are rapidly evaluated by our multidisciplinary "Shock Team," which consists of cardiac surgeons, interventional and heart failure cardiologists, nurse practitioners, and intensive care physicians, to determine the most suitable ST-MCS device for each patient. We prefer to use a CentriMag (Thoratec Corp, Pleasanton, Calif) ventricular assist device or venoarterial extracorporeal membrane oxygenation (ECMO).[7,8] During this study period, other percutaneous devices such as the Impella (Abiomed Inc, Danvers, Mass) and the TandemHeart (CardiacAssist Inc, Pittsburgh, Pa) were used in the catheterization laboratory because of sudden hemodynamic collapse during the interventional procedure or used in other hospitals.

Indication and Surgical Technique of Extracorporeal Membrane Oxygenation and CentriMag Device

The indication and implantation technique for ECMO and CentriMag device have been reported.[7,8] ECMO is chosen when a patient has unclear neurologic status, has hemodynamics too unstable to allow a safe transfer to the operating room, has developed severe coagulopathy because of shock liver with a sudden and marked elevation in liver enzyme levels, or has received antiplatelet therapy before percutaneous coronary intervention. Depending on the clinical status of the patient, the ECMO device is placed at the bedside, at the catheterization laboratory, or in the operating room by surgeons. Femoral access is the first choice for peripheral cannulation. The ECMO circuit consists of a Quadrox D oxygenator (Maquet, Wayne, NJ), Rotaflow (Maquet), and SMART-coated tubing (Sorin, Milan, Italy). Biomedicus femoral cannulas (Medtronic, Minneapolis, Minn) are used. Arterial cannula sizes of 15F to 23F and venous cannula sizes of 19F to 25F are used. A distal perfusion cannula is selectively inserted through a cut-down to the superficial femoral artery whenever there is the lack of a strong Doppler signal on the ipsilateral foot.

During this study period, the standard surgical approach for CentriMag device implantation was through a sternotomy using cardiopulmonary bypass. Biventricular support was an essential configuration for patients in cardiogenic shock. Double purse-string sutures with 2-0 or 3-0 polypropylene buttressed with bovine pericardial pledgets were placed at the cannulation sites and passed through DLP tourniquets (Medtronic, Inc). For the LVAD, the inflow cannula (28F-40F) was inserted into the left ventricular (LV) apex. An 8- or 10-mm Dacron graft was sewn onto the ascending aorta. The outflow cannula (18F-24F) was inserted through the graft and secured with silk ties. For the right ventricular assist device (RVAD), the inflow cannula (28F-31F) was inserted into the right atrium, and the outflow cannula (18F-24F) was inserted into the main pulmonary artery. The cannulas were secured to the tourniquets with 0 silk ties. These tourniquets were folded and tied with another 0 silk tie onto the cannula at their entry point to the posterior aspect of the rectus abdominis muscle fascia, which prevented cannula dislodgement and allowed ambulatory rehabilitation.

Anticoagulation with intravenous heparin is initiated at the rate of 300 U/h once coagulopathy is reversed or the chest tube drainage becomes