Outcomes of Patients Receiving Temporary Circulatory Support Before Durable Ventricular Assist Device

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Background. **Temporary circulatory support (TCS) is used to stabilize patients in critical cardiogenic shock and bridge patients to a durable ventricular assist device (VAD). Whether TCS confers increased risk at the time of VAD implant is unknown.**

Methods. **Prospectively collected data from five institutions was retrospectively reviewed. All profile 1 through profile 3 patients implanted with a continuous-flow VAD (n = 804) were categorized into three groups: TCS (n = 68); non-TCS profile 1 (n = 70); and non-TCS profile 2-3 (n = 666).**

Results. **End-organ function and hemodynamics were worse before TCS than in non-TCS profile 1 patients: creatinine (1.7 ± 0.1 mg/dL versus 1.3 ± 0.06 mg/dL, $p = 0.003$); and right atrial pressure (16 ± 0.8 mm Hg versus 13 ± 1.1 mm Hg, $p = 0.048$). The TCS restored cardiac output before durable VAD (4.9 ± 0.2 L/min), and was comparable to profile 2-3 patients (4.3 ± 0.05 L/min) and better than profile 1 patients (4.0 ± 0.2 L/min, $p = 0.002$). Markers of hepatic function such as bilirubin were impaired before VAD in TCS and profile 1 patients (2.0 ± 0.2 mg/dL) compared with profile 2 and 3 patients (1.1 ± 0.03, $p < 0.001$). The incidence of postoperative right ventricular failure necessitating a right VAD was 21% for TCS patients and non-TCS profile 1 patients compared with 2% for profile 2-3 patients ($p < 0.001$). Profile 1 and TCS patients had similar 1-year survival (70% and 77%, $p = 0.57$), but inferior survival as compared with profile 2 and 3 patients (82%, $p < 0.001$). On multivariable analysis, TCS increased the hazard of death twofold.**

Conclusions. **Temporary circulatory support restores hemodynamics and reverses end-organ dysfunction. Nevertheless, these patients have high residual risk with postoperative morbidity and mortality that parallels profile 1 patients without TCS. Caution is suggested in downgrading risk for TCS patients with improved hemodynamic stability.**

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Cardiogenic shock is associated with a high mortality rate. For patients receiving a durable ventricular assist device (VAD), shock characterized by Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) profiles 1 and 2 has a 1.7 times and 1.4 times higher mortality, respectively, as compared with more stable patients in profiles 3 through 7 [1]. In the past decade there has been an increased utilization of temporary circulatory support (TCS) devices such as extracorporeal membranous oxygenation (ECMO) and percutaneous VAD (pVAD) with an aim to improve cardiopulmonary hemodynamics and end-organ function before more durable cardiac interventions, including long-term durable VAD [1, 2]. Certain TCS devices provide full cardiac support for patients with isolated left ventricular or biventricular failure, permitting time for clinical evaluation and decision making before proceeding with durable VAD implant.

Whether improved clinical stability before durable VAD implant improves perioperative outcomes, imparts a reduction in morbidity, or improves short-term survival

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Abbreviations and Acronyms

CI	= confidence interval
ECMO	= extracorporeal membrane oxygenation
HR	= hazard ratio
IABP	= intraaortic balloon pump
INTERMACS	= Interagency Registry for Mechanically Assisted Circulatory Support
MCSRN	= Mechanical Circulatory Support Research Network
pVAD	= percutaneous ventricular assist device
RVAD	= right ventricular assist device
TCS	= temporary circulatory support
VAD	= ventricular assist device

after durable VAD implant is poorly defined in the literature. To capture the use of TCS as a bridge-to-bridge strategy, the INTERMACS registry introduced the TCS qualifier in 2009 for any durable VAD patient within INTERMACS profiles 1, 2, and 3 [3]. The TCS qualifier can be applied to any patient supported with TCS, including an intraaortic balloon pump (IABP), ECMO, pVAD, or temporary extracorporeal VAD.

To help elucidate outcomes of patients on TCS before durable VAD implantation, we performed an analysis of the Mechanical Circulatory Support Research Network (MCSRN). Our goals were to describe the severity of illness in patients supported with TCS before durable VAD, determine the prognostic power of the TCS modifier, and contrast clinical outcomes after durable VAD implant between patients with and patients without TCS.

Patients and Methods

Each of the five VAD centers that comprise the MCSRN (University of Michigan, Inova Heart and Vascular Institute, Mayo Clinic, Vanderbilt University, and St. Vincent's Heart Center of Indiana) has individual Institutional Review Board protocols in place that permit prospective data collection of durable VAD recipients. The protocols comply with ethical guidelines outlined in the 1975 Declaration of Helsinki and the Health Insurance Portability and Accountability Act (HIPAA). Data are shared through a data use agreement and collected for analysis at a central data coordinating center managed through Vanderbilt University.

Data on 1,064 continuous-flow durable VAD recipients from May 2004 to September 2014 were available for this retrospective analysis. Pulsatile-flow VADs were excluded, and only modern generation continuous-flow devices were included: HVAD (HeartWare, Framingham, MA) and HeartMate II (Thoratec, Pleasanton, CA). Patients were grouped according to INTERMACS profile and utilization of TCS support. INTERMACS profiles 4 through 7 patients were excluded (n = 260) as the TCS modifier is not applicable to these patient profiles. We included the pVADs TandemHeart (CardiacAssist, Pittsburgh, PA) and Impella (Abiomed, Danvers, MA), ECMO, and temporary extracorporeal VADs (CentriMag; Thoratec) in our TCS group. Because data on the indication for IABP use, whether for hemodynamic instability or for prophylaxis reasons, were not captured in the MCSRN registry, IABPs were excluded from the TCS group. Baseline demographics, laboratory values, implant characteristics, and follow-up events for VAD recipients were obtained from the registry.

Definition of Post-VAD Outcomes

The effect of TCS on post–durable VAD operative and long-term mortality was assessed. Operative mortality was defined as death within 30 days of durable VAD implant or during the index implant hospitalization. Renal failure was defined as the need for renal replacement therapy during the index implant hospitalization. Right-sided circulatory failure was defined as the need for right ventricular assist device (RVAD), temporary or permanent. Other adverse events after durable VAD implant were also evaluated: gastrointestinal bleeding, cerebrovascular accidents, infections, and suspected or confirmed device thrombosis per INTERMACS definition.

Statistical Analysis

Baseline data are presented as the mean with standard error or median with interquartile range for continuous variables based on normality of the distribution. Normality testing of continuous variables was determined using the Shapiro-Wilk test. Mean values were compared using the independent samples Student's t test or analysis of variance method and medians with the Mann-Whitney U test or Kruskal-Wallis test. For categoric values, numbers with proportions are presented. Proportions were compared using Fisher's exact test or Pearson's test for more than two-by-two comparisons. Kaplan-Meier methods were used to generate event-free survival curves, censoring patients at the time of transplant or explant for recovery. Breslow and log rank testing was used for curve comparison [4].

Cox regression was used to compare adjusted mortality in patients based on INTERMACS patient profiles, focusing on the presence of the TCS modifier. Other variables in the model included age, sex, body mass index, device indication, INTERMACS profile, albumin, and bilirubin. Hazard ratios (HR) with 95% confidence interval (CI) are provided. A two-sided p value of less than 0.05 was considered to represent statistical significance. All data were analyzed using SPSS 22.0 (IBM Corp, Armonk NY).

Results

MCSRN Patient Characteristics

Within the MCSRN registry, 804 patients included in the analysis were followed for 1,127 patient-years of support, with a median support duration of 1 year. There were 327 patients (41%) who were supported with an IABP before durable VAD. Twenty-nine patients were supported with