Hemodynamic Support with Percutaneous Devices in Patients with Heart Failure

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KEYWORDS

• Percutaneous mechanical support • Impella • TandemHeart • ECMO • Cardiogenic shock
• Refractory heart failure • Decompensated heart failure • Assist device

KEY POINTS

- The use of surgically implanted durable mechanical circulatory support (MCS) in high-risk patients with heart failure is declining and short-term, nondurable MCS device use is growing.
- Percutaneously delivered MCS options for advanced heart failure include the intra-aortic balloon pump, Impella axial flow catheter, TandemHeart (TH) centrifugal pump, and venoarterial extracorporeal membrane oxygenation.
- Each nondurable MCS device has unique implantation characteristics and hemodynamic effects on left ventricular function.
- Algorithms and guidelines for optimal nondurable MCS device selection do not exist.
- Emerging technologies and applications will address the need for improved left ventricular unloading using lower-profile devices, longer-term ambulatory support, and the potential for myocardial recovery.

Videos of TandemHeart Pump and Impella RP (Investigational) Pump implantation accompany this article at http://www.heartfailure.theclinics.com

ADVANCED HEART FAILURE AND CARDIOGENIC SHOCK

An estimated 2.6% of the American population and nearly 11% of the elderly population more than 80 years of age experiences heart failure, which is defined as a syndrome caused by cardiac dysfunction, generally resulting from myocardial muscle dysfunction or loss and characterized by either left ventricular dilatation or hypertrophy or both.[1] By 2030, more than 8 million people in the United States (1 in every 33) will be diagnosed with heart failure.[2] The clinical spectrum of heart failure often begins with an initial event such as acute myocardial infarction (AMI), progressive valvular heart disease, myocarditis, or onset of a primary dilated cardiomyopathy. With initial medical stabilization, these patients often survive to develop chronic heart failure, which is characterized by neurohormonal activation, increased sympathetic tone, and maladaptive cardiac remodeling, and, despite optimal medical therapy,

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ultimate leads to recurrent hospitalizations for acute-on-chronic heart failure and death. At both ends of this clinical spectrum, low cardiac output and multiorgan hypoperfusion are primary indications for the use of advanced therapies, including durable mechanical circulatory support (MCS) devices, which include surgically implanted left, right, or biventricular assist devices, or cardiac transplantation.

In the United States, cardiac transplant volumes have remained stable at approximately 2000 to 2500 per year. In contrast, based on supportive data from the HeartMate-II and Heartware bridge to transplant (BTT) trials and the HeartMate-II destination therapy trial, left ventricular assist device (LVAD) use increased to more than 2500 implants in 2013 in the United States alone.[3] Prospective registry data from the Interagency for Mechanically Assisted Circulatory Support (INTERMACS) reports an increase in the use of LVADs for so-called destination therapy and a reduction in their use as part of a bridge to recovery or rescue strategy (Fig. 1). This shift in LVAD use away from unstable, high-risk INTERMACS profiles (1 and 2) toward more stable candidates (profiles 3 and 4) is partly driven by data showing increased mortality after LVAD implantation for INTERMACS profiles 1 and 2 after the age of 65 years and the increasing availability of nondurable MCS devices, which include short-term, percutaneously inserted devices without the need for cardiac surgery (see Fig. 1). Potential indications for nondurable MCS in patients with advanced heart failure being considered for durable MCS are listed in Box 1.

Consistent with this observation, a recent analysis of the Nationwide Inpatient Sample from the Healthcare Cost and Utilization Project identified a 1511% increase in the use of nondurable MCS devices, including the TandemHeart (Cardiac Assist Inc) and Impella (Abiomed Inc), and no significant change in intra-aortic balloon pump (IABP) use from 2007 to 2011 compared with 2004 to 2007 (Fig. 2).[4] Use of the TandemHeart and Impella devices was associated with a reduced length of stay and cost for patients admitted with a diagnosis of congestive heart failure, but no change in in-hospital mortality. Primary predictors of mortality included advanced age, coagulopathy, metabolic dyscrasia, a diagnosis of cardiogenic shock, and IABP use or cardiopulmonary resuscitation before application of the TandemHeart or Impella devices. This article provides a fundamental understanding of the nondurable MCS device options, hemodynamic effects, candidate selection, and supportive clinical trials in patients with advanced heart failure.

CLASSIFICATION AND INDICATIONS FOR NONDURABLE MECHANICAL CIRCULATORY SUPPORT IN HEART FAILURE

The primary goals of nondurable MCS devices are to (1) increase vital organ perfusion, (2) augment coronary perfusion, and (3) reduce ventricular volume and filling pressures, thereby reducing wall stress, stroke work, and myocardial oxygen consumption. Clinical scenarios in

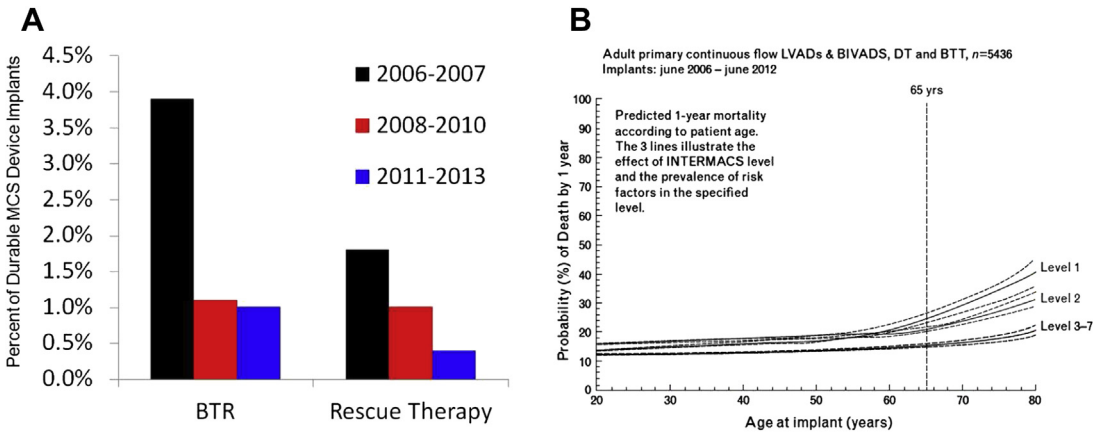

Fig. 1. Trends in the use of durable MCS. (*A*) Since 2006, use of surgically implanted durable MCS as a bridge to recovery (BTR) or as rescue therapy is declining, caused in part by (*B*) higher 1-year predicted mortality in patients more than 65 years of age who present with INTERMACS level 1 or 2 advanced heart failure. BIVADS, biventricular assist devices; DT, destination therapy. (*From* Kirklin JK, Naftel DC, Kormos RL, et al. Fifth INTERMACS annual report: risk factor analysis from more than 6,000 mechanical circulatory support patients. J Heart Lung Transplant 2013;32:144, 147; with permission.)