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9

Mechanical circulatory support

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Heart failure (HF) is a condition in which the heart is not able to pump enough blood and oxygen required for organ systems to function. According to recent statistics from the American Heart Association (AHA), about 5.1 million people in the nation suffer from HF; one in nine deaths in 2009 included HF as a contributing cause. About half of people who develop HF die within 5 years of diagnosis. HF costs the nation an estimated $32 billion each year. This total includes the cost of health-care services, medications to treat HF, and missed days of work [1]. Despite several recent promising developments in medical therapy for HF, many patients still progress to advanced stages of HF. The annual mortality rate for patients with advanced HF remains high [2].

Heart transplantation (HT) is the definitive therapy for advanced HF, but it is limited by the availability of donors and strict recipient criteria applied to avoid poor outcomes. Therefore, the alternate treatment of mechanically supporting the ventricles, ventricular assist device (VAD) therapy, has gained an important role in the management of advanced HF (stage D). This chapter discusses the indications, contraindications, and various classifications of mechanical circulatory support (MCS) and individual features of commonly used VADs. Perioperative management of patients undergoing MCS will also be described in detail.

Indications and categories of mechanical circulatory support

Heart failure (HF) is a well-recognized costly public health problem with high patient mortality [1,2]. Patients with heart failure symptoms refractory to optimum medical treatment are referred for mechanical circulatory support therapy. According to Interagency Registry for Mechanically Assisted

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Table 1
Intermacs patient profiles for end-stage heart failure.

Profile	Clinical picture
1	Critical cardiogenic shock. Life-threatening hypotension, increasing requirement for inotropes with evidence of organ hypoperfusion (elevated lactate levels and acidosis). Patients need MCS in hours.
2	Progressive decline on inotropes with evidence of volume overload, poor tolerance to increasing doses of inotropes and impaired organ perfusion. Patient will need VAD support in few days.
3	Clinical stability on moderate dose of inotropes or temporary circulatory support, can be hospitalized or at home. VAD support indicated in weeks.
4	Recurrent advanced heart failure – resting symptoms on home oral therapy. VAD support is indicated in weeks or months.
5	Exertion intolerant – comfortable at rest, but ADL limited by symptoms. VAD support requirement is variable.
6	Exertion limited – ADL not limited, but all meaningful exertion limited. VAD support requirement is variable.
7	History of decompensation but currently stable at reasonable level of activity (advanced NYHA Class 3). VAD implantation has been shown to improve survival.

ADL, Activity of Daily Living.
NYHA, New York Heart Association.

Circulatory Support (Intermacs) statistics, about 12,474 ventricular assist devices (VADs) were implanted across 149 participating programs in the United States between June 2006 and September 2014 [3]. Intermacs classified severe heart failure (HF) into seven subcategories to describe patient status before VAD implantation (Table 1). Potential modifiers for the clinical profiles include frequent shocks (>2 per week) by a defibrillator, requirement for any form of temporary circulatory support (TCS) (applies to profiles one, two, and three), and frequent hospitalizations (three visits in <6 months applies to profiles four, five, and six). Patient profiles two and three accounted for 65% of VAD patients in the recent report; 17.7% of patients were profile one and 13% were profile four.

Once a patient receives VAD support for severe HF, they either wait for a suitable donor (bridge to transplant (BTT)) or live with VAD life support (destination therapy (DT)). About 5–10% of patients can be successfully weaned off VAD support (bridge to recovery (BTR)) [4]. The device strategies are classified in Table 2. When mechanical circulatory support (MCS) became an established therapy for HF, most of the VADs were inserted with the hope of getting heart transplantations (HTs) for the patients. The outlook has changed over the past 3–4 years because of evidence that DT improves survival and quality of life in New York Heart Association (NYHA) class IV and class IIB patients [29]. DT accounted for most VAD implantations, outnumbering bridging indications from 2011 onwards, when the US Food and Drug Administration (FDA) approved the Heartmate II (HM II) for DT [3].

Besides the indications defined by Intermacs patient profiles (acute and chronic HFs from various causes), several other clinical circumstances require MCS, including high-risk percutaneous transluminal coronary angioplasty and complicated valvular/revascularization procedures. MCS is used to

Table 2
Device strategy at the time of VAD implantation.

1. Bridge to Transplant (BTT) Listed – patient already listed for transplant or listed within 24 h before device implantation.
2. Bridge to Transplant (BTT) Likely – patient in whom the transplant evaluation has not been completed, but no contraindications are anticipated, or in whom a current contraindication is anticipated to resolve rapidly.
3. Bridge to Transplant (BTT) Moderate – patient in whom the transplant evaluation has not been completed, but with some potential concerns that might prevent eligibility.
4. Bridge to Transplant (BTT) Unlikely – patient in whom major concerns that might prevent eligibility have already been identified.
5. Destination Therapy (DT) – the patient is definitely not eligible for transplant.
6. Bridge to Recovery (BTR) – the use of a durable device to allow recovery from chronic cardiac failure (at least 3 months in duration).
7. Rescue Therapy – the use of a durable device to support resolution from an acute event without major previous cardiac dysfunction.
8. Other.