Advances and Future Directions for Mechanical Circulatory Support

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KEYWORDS

• Mechanical circulatory support • Ventricular assist device • Axial flow • HeartMate II • HeartWare

KEY POINTS

- Second-generation axial flow ventricular assist devices (VADs) have demonstrated increased durability relative to first-generation devices.
- Advantages of second-generation and third-generation VADs include fewer moving parts, smaller size, lower infection rates, and silent operation.
- With the ongoing shortage of donor organs, current generations of VADs show promise as alternatives to transplant in select patients.
- Appropriate risk assessment can assist in the proper selection of VAD candidates.
- Echocardiography is indispensable in the perioperative management of VAD patients.

INTRODUCTION

Although cardiac transplant remains the gold standard for the treatment of end-stage heart failure, limited donor organ availability and growing numbers of eligible recipients have increased the demand for alternative therapies. This is in spite of the use of older and more high-risk donor hearts, DCD (donors after circulatory determination of death) hearts,[1,2] and the use of the newer Organ Care System (TransMedics Inc, Andover, MA, USA) "heart-in-a-box" technique, in which the donor heart is perfused at the time of harvest to allow for prolongation of the ischemic time and for acceptance of organs from longer geographic distances. At present, the number of heart transplant operations performed in the United States has remained constant at approximately 2200 per year, and there has been a steady decline in the number of these procedures over the past 15 years.[3]

Following the 2001 landmark publication of the REMATCH trial (Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure),

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which compared optimal medical management to device therapy in nontransplant candidates with end-stage heart failure, it became apparent that mechanical cardiac assist would become a viable alternative in properly selected patients.[4] The results of the REMATCH trial ultimately led to United States Food and Drug Administration (FDA) approval of the HeartMate XVE (Thoratec Corporation, Pleasanton, CA, USA) for destination therapy in November 2002, followed by approval for Medicare coverage for the same indication in October 2003.

The following sections discuss 2 rotary devices in current use: the HeartMate II (Thoratec Corporation, Pleasanton, CA, USA) and the newer investigational HeartWare HVAD (HeartWare, Inc, Miami Lakes, FL, USA).

SECOND-GENERATION VENTRICULAR ASSIST DEVICES

The first generation implantable VADs were pulsatile volume displacement pumps. Despite being successful as bridges to transplant, they were limited by several adverse events, including infection, thromboembolism, and mechanical failure.

The introduction of axial flow pumps, which include the HeartMate II, the Jarvik 2000 Flowmaker (Jarvik Heart, Inc, New York, NY, USA), and the MicroMed DeBakey (MicroMed Cardiovascular, Inc, Houston, TX, USA), eliminated several problems encountered with earlier-generation devices. The HeartMate II has been the most successful of these pumps[5] and received FDA approval for destination therapy in January 2010. The following are its advantages over first-generation devices:

- Fewer moving parts (the rotor is the only moving part)
- Wear-resistant bearings
- Small size and weight, allowing for implantation in smaller patients
- Silent operation
- Decreased power consumption
- More comfortable
- Smaller driveline, resulting in lower infection rates
- Relatively low rate of thromboembolism
- Lack of valves and reservoir chamber, with potentially increased durability

INDICATIONS

Bridge to Transplant

VAD support as a bridge to transplant has increased significantly in recent years. Patients awaiting cardiac transplant and who are managed medically may require VAD rescue if their condition deteriorates. In a US study of 3711 United Network for Organ Sharing status 1A patients between January 2000 and December 2006, of whom 2208 were initially medically managed and 1503 were supported with a VAD as a bridge to transplant, 20% of the medically treated patients went on to require VAD support. VAD support in medically managed status 1A patients was associated with a significantly greater probability of survival and/or transplant at 3 months (66.5%–87.1% increased probability). This observation has led to the suggestion that earlier/elective institution of VAD support in medically managed status 1A patients should be considered in those at greater risk of death or with long expected waiting times for organ availability.[6] In our center, nearly 40% of patients are supported with a left ventricular assist device (LVAD) at the time of transplant.

In patients who are not candidates for cardiac transplant because of pulmonary hypertension, some studies have demonstrated a reduction in pulmonary vascular