Mechanical Circulatory Support in Advanced Heart Failure: Single-Center Experience

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ABSTRACT

Background. Currently, ventricular assist device (VAD) or total artificial heart (TAH) mechanical support provides an effective treatment of unstable patients with advanced heart failure. We report our single-center experience with mechanical circulatory support therapy.

Methods. From March 2002 to December 2012, 107 adult patients (mean age, 56.8 ± 9.9 y; range, 31–76 y) were primarly supported on temporary or long-term VAD or TAH support as treatment for refractory heart failure at our institution. Temporary extracorporeal radial VAD support (group A) was established in 49 patients (45.7%), and long-term paracorporeal and intracorporeal VAD or TAH (group B) in 58 patients (54.2%). Left ventricular (LVAD) support was established in 55 patients (51.4%; n = 33, Heartmate II; n = 6, Heartmate I XVE; n = 4, Heartware HVAD; and n = 12, Centrimag) and biventricular (BVAD/TAH) support (group B) in 28 patients (26.1%; n = 10, Thoratec paracorporeal; n = 2, Heartware HVAD, n = 1, Thoratec implantable; n = 1, Syncardia TAH; and n = 14, Centrimag). The temporary Centrimag was the only device adopted as isolated right ventricular (RVAD) support, and it was inserted in 24 patients (22.4%).

Results. In group A, overall mean support time was 10.2 ± 6.6 days (range, 3–43 d). In group B, LVAD mean support time was 357 ± 352.3 days (range, 1–902 d) and BVAD/TAH support time was 98 ± 82.6 days (range, 8–832 d). In group A, the overall success rate was 55.1% (27 patients). In group B, LVAD overall success rate was 74.4% (32 patients) and BVAD/TAH success rate was 50% (7 patients). Overall heart transplantation rate for both groups was 27.1% (n = 2, group A; n = 27, group B). Overall 1-year and 5-year survivals after heart transplantation were 72.4% (n = 21) and 58.6% (n = 17), respectively.

Conclusions. Mechanical circulatory support is an effective strategy even in cases of end-stage heart failure according to our experience. Further improvement of VAD and TAH technologies may support their adoption as an encouraging alternative to heart transplantation in the near future.

MECHANICAL CIRCULATORY SUPPORT (MCS) for patients (patients) with advanced heart failure has evolved considerably during the past 5 decades since DeBakey's first successful use of a ventricular assist device (VAD) in 1966 for bridge to recovery in post-cardiotomy syndrome in a 37-year-old woman [1–4]. MCS is now the standard therapy for treatment of acute or chronic end-stage heart failure at many medical centers worldwide, with more MCS systems being implanted than hearts transplanted in Europe, which will also be the case in the near future in North America [1–4]. We report our 10-year single-center experience with MCS therapy.

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0041-1345/14/$–see front matter
http://dx.doi.org/10.1016/j.transproceed.2014.01.016

Table 1. Levitronix Centrimag Short-Term Mechanical Support System Population and Outcomes

	Type of Mechanical Support	Duration of Support (d, mean ± SD)	Weaned From Support	Bridged to HT	Died on Support	Discharged
Post-cardiotomy HF	RVAD, $n = 10$	8.9 ± 5.6 (overall)	$n = 6$	–	$n = 4$	$n = 6$
	BVAD, $n = 9$		$n = 4$	$n = 1$	$n = 4$	$n = 4$
	LVAD, $n = 7$		$n = 3$	–	$n = 4$	$n = 2$
RV failure after LVAD	RVAD, $n = 14$	16.4 ± 9.6 (overall)	$n = 12$	–	$n = 2$	$n = 11$
Acute donor HF	BVAD, $n = 2$	7.7 ± 0.9 (overall)	$n = 2$	–	–	$n = 1$
	LVAD, $n = 2$		$n = 2$			$n = 2$
Post-AMI HF	BVAD, $n = 3$	8.6 ± 4.3 (overall)	–	$n = 1$	$n = 2$	$n = 1$
	LVAD, $n = 2$		–	–	$n = 2$	–

Abbreviations: AMI, acute myocardial infarction; BVAD, biventricular assist device; HF, heart failure; HT, heart transplantation; LVAD, left ventricular assist device; RVAD, right ventricular assist device; RV, right ventricular.

METHODS

From March 2002 to December 2012, 107 adult patients (mean age, 56.8 ± 9.9 y; range, 31–76 y) were primarily supported on temporary or long-term VAD or total artificial heart (TAH) support as treatment for refractory heart failure at our institution (Tables 1 and 2). Temporary extracorporeal radial VAD support (group A) was established in 49 patients (45.7%) and long-term paracorporeal and intracorporeal VAD or TAH support (group B) in 58 patients (54.2%). Body surface area of the overall patient population was 1.75 ± 0.19 m^2 (range, 1.54–1.99 m^2).

In group A, the temporary Levitronix Centrimag (Levitronix, Waltham, Massachusetts) radial-flow pump was used in a left-, right-, or bi-ventricular assist device (LVAD, RVAD, or BVAD) configuration. In group B, the following long-term LVAD systems were used: Heartmate I XVE (Thoratec, Pleasanton, California), Heartmate II (Thoratec), and Heartware HVAD (Heartware, Miramar, Florida). For biventricular support the following long-term systems were used in group B: Thoratec paracorporeal and implantable VADs, Heartware HVAD, and Syncardia TAH (Syncardia Systems, Tucson, Arizona).

The VAD and TAH systems were surgically placed in traditional fashion as described elsewhere [5–10]. We adopted the anticoagulation protocol proposed by each device company [5–10]. Written informed consent was obtained from every patient before surgery.

LVAD support was established in 55 patients (51.4%; $n = 33$, Heartmate II; $n = 6$, Heartmate I XVE; $n = 4$, Heartware HVAD; and $n = 12$, Centrimag) and BVAD/TAH support (group B) in 28 patients (26.1%; $n = 10$, Thoratec paracorporeal, $n = 2$, Heartware HVAD; $n = 1$, Thoratec implantable; $n = 1$, Syncardia TAH; and $n = 14$, Centrimag). The temporary Centrimag was the only device adopted as isolated RVAD support, and it was inserted in 24 patients (22.4%; $n = 10$ in the postcardiotomy cohort; $n = 14$ in the long-term LVAD cohort).

In group A, indications for support were: failure to wean from cardiopulmonary bypass ($n = 44$) after cardiotomy ($n = 26$), primary donor graft failure ($n = 4$) or right ventricular (RV) failure after axial or centrifugal LVAD placement ($n = 14$); and ($n = 5$) refractory heart failure after acute myocardial infarction (AMI). In group B, indication at implantation were: ischemic dilative cardiomyopathy (DCMP) in 31 patients, idiopathic DCMP in 25 patients, and post-myocarditis DCMP in 2.

At time of implantation Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) level was 1 in all patients of group A, 2 in 4 of the LVAD patients and 5 of BVAD/TAH patients of group B, and 3 in the rest of VAD/TAH patients of group B. The majority of patients received an intra-aortic balloon pump support before VAD therapy (83.1%; $n = 40$ in group A; $n = 49$ in group B) according to Haussman score [1,2,11]. Overall, 14 patients (13.08%) had undergone earlier open heart surgery ($n = 9$ in group A; $n = 5$ in group B). Regarding preoperative vital status of patients, the Simplified Acute Physiology (SAPS) II score [1,2,10] was 18.7 (range, 10–31) in LVAD patients and 30.6 (range, 26–45) in BVAD/TAH patients. The preoperative inotropic score [1,2] was 16.2 (range, 10–27) in LVAD patients and 28.5 (range, 20–45) in BVAD/TAH patients. Preoperative laboratory N-terminal pro–B-type natriuretic peptide (NT-proBNP) [1,2] was 8,610 pg/mL (range, 5,215–10,233 pg/mL) in LVAD patients and 13,780 pg/mL (range, 10,110–18,455 pg/mL) in BVAD/TAH patients. Regarding RV function assessment, preoperative Michigan and Pennsylvania scores, as described elsewhere in terms of personal adoption [2,10], were, respectively, 3.1 (range, 2.2–4.0) and 32.7 (range, 24–45) in LVAD patients and 5.6 (range, 4.1–6.1) and 54.6 (range, 49.4–62) in BVAD/TAH patients. Preoperative RV short to long axis ratio (S/L ratio) >0.65 and right ventricle–to–left ventricle end-diastolic diameter ratio (R/L ratio) <0.72 by echo assessment were considered to be potential risk factors for postoperative RV failure after LVAD placement, and BVAD or TAH support was preferred according to Berlin algorithm as reported elsewhere [1,2,10].

Statistical Analysis

Categoric variables are expressed as number and percentage of patients. Continuous variables are given as mean and standard deviation. The Kaplan–Meier method was used to calculate the survival curves and to determine survival outcomes for permanent VAD patients and transplanted patients who got no VAD support before. All analyses were performed using SPSS for Windows Release 11.5 (SPSS Inc., Chicago, IL).

Table 2. Long-Term Implantable VAD or TAH System Outcomes

Type of Mechanical Support	Duration of Support (d, mean ± SD)	Early Death	Discharge	Permanent Support (DT)	Recovery	HT	Late Death
LVAD, $n = 55$	357 ± 352.3	$n = 7$	$n = 32$	$n = 7$	$n = 1$	$n = 21$	$n = 7$
BVAD, $n = 13$	96 ± 72.4	$n = 7$	$n = 1$	–	–	$n = 5$	$n = 1$
TAH, $n = 1$	832	–	$n = 1$	–	–	$n = 1$	–

Abbreviations: DT, destination therapy; TAH, total artificial heart; others as in Table 1.