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CASE REPORT

Implantation of a HeartMate 3 in a 13-Year-Old Child with Dilated Cardiomyopathy

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Abstract
Left ventricular assist device is a well-established therapy in heart failure adults, but less in children. A 13-year-old-boy with severe left ventricular dysfunction did not improve under medical treatment. A HeartMate 3 (HM3) was implanted as a bridge to transplantation. Despite the size limitation, the HM3 shows promising results and our case supports its feasibility in children.

Keywords HeartMate 3 · LVAD · Heart failure · Bridge to transplant

Introduction

Treatment of end-stage heart failure (HF) with a left ventricular assist device (LVAD) is a well-established therapy in adult patients. Paracorporeal systems are usually preferred in children because of the size of the LVAD [1]. In recent years, the size of continuous-flow pumps has been decreased, allowing for their implantation in children [2].

The HM3 is a LVAD with full magnetic levitation, allowing for wide and consistent blood flow paths. An artificial pulse was designed for enhanced hemocompatibility. One-year HM3 results showed that adverse events in adults were similar to those of other devices without any pump thrombosis, malfunction, or haemolysis [3].

The pump weighs 200 g with a diameter of 50.3 mm and height 33.8 mm. The flow rate ranges from 2.5 to 10 L/min.

Case Presentation

A 13-year-old-boy weighing 59 kg (BSA 1.7 cm^2), with known dilated cardiomyopathy with family history, was admitted in decompensated HF. The patient presented severely reduced left ventricular (LV) ejection fraction (19%) and a type IIIb moderate-to-severe MR (Video 1). LV end-diastolic diameter was 7.7 cm (z-score 6.9). INTERMACS score was 3. Treatment with levosimendan and milrinone was unsuccessful.

After median sternotomy and central cardiopulmonary bypass initiation, the LV was cored near the apex with a beating heart. The sewing ring was sewn by 12 Ti-Cron threads on a felt strip. The pump was then fixed to the ring. The driveline was tunnelized to the left lower quadrant. Then, the aorta was clamped, and cardiac arrest was obtained with cold blood cardioplegia. The outflow graft was sewn with 5.0 polypropylene to the ascending aorta. After de-airing and unclamping, the pump was started at 3000 rpm and slowly increased to the desired flow rate of 5200 rpm. The procedure was well tolerated, especially by the right ventricle. Orientation of the LVAD was good even in a child chest (Video 2).

Unfractionated heparin was started after 6 h as a bridge to oral anticoagulation. Aspirin was initiated on postoperative day 2. Extubation was performed after 41 h.

The recovery was excellent, except a superficial driveline infection treated by antibiotics for 14 days. Heart transplantation was performed after 11 months with uneventful recovery.

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Discussion

Development of pediatric ventricular assist devices has been always slower, especially because of the size of the intended recipients. Introduction of the Berlin Heart EXCOR has provided the opportunity to support one or two ventricles with good results in children up to 3 kg. However, the rate of complications remains high, with an adverse event of 0.06 to 0.09 per patient-day, primarily bleeding, infections, and strokes [4]. Quality of life is also suboptimal, with pediatric patients needing to stay at hospital until transplantation can occur.

Outcomes for the HM2 described by Cabrera et al. were very good, with 96% survival at 6 months (transplanted, recovery, and ongoing support) [5]. The smallest child implanted had a BSA as low as 1.1 m^2. Concerning the HeartWare, Miera et al. presented excellent results, with successful bridging to transplantation with a low rate of complication. The smallest patient had a BSA of 0.7 cm^2 (weight 17 kg) and a pump flow of 2.3 L/min [2]. Smaller children are perhaps not candidates for this system, due to the minimum flow rate of 2 L/min, limiting its use in patients under 17–20 kg.

Reports of the HM3 in adult patients showed promising results, with few pump thrombosis, few pump malfunction, and no haemolysis. Its unique features with a full magnetically levitated rotor potentially reduces shear forces characteristic of current continuous-flow LVADs that are known to potentially damage red blood cells and von Willebrand factor and to activate platelets [3]. These results in the adults should encourage implantation in the pediatric population. One possible limitation is the flow, as is the case with the HeartWare, which is approximately 2.0–2.5 L/min, rendering its use in patients under 20 kg likely difficult. However, HM3 uses full magnetic bearings, which might be advantageous in chronic low flow situations, comparing to the HeartWare, which uses magnetic and hydrodynamic bearings, rendering the impeller less stable and producing more friction between the impeller and the pump. Even with these limitations, HeartWare was implanted in a 6-year-old child of 17 kg and BSA of 0.7 cm^2 with a median flow of 2.3 L/min [2]. Burki collected few cases of HeartWare implantation in children with a BSA as low as 0.6 cm^2 and reported a case of 4-year-old and 13 kg.[6]. Considering the flow, the limit concerning the HM3 is similar to the HeartWare and in specific situations, the HM3 could be implanted in such small patients.

The other limitation for the HM3 is its size, with a pump height of 33.8 mm, compared to 23.7 mm in the HeartWare. But, in small patients, the more important point is the size of the LV cavity. As the inflow cannula of the HM3 and the HeartWare have similar dimensions (25 mm length), the HM3 might be implanted in similar patients. As noted by Chivukula et al., the most important is the orientation of the cannula with better hemodynamics in patients with an angle less than 7° from the apical axis [7]. The size of the pump is still 1 cm larger in the HM3. If we consider the HeartMate II, Ono et al. confirmed the feasibility down to 1.23 cm^2 BSA if careful implantation technique was performed with an appropriate pocket in the left subcostal area. As the HeartMate II requires the same or even more space than the HM3, this suggests that the HM3 could be implanted at least in patients over 1.2 cm^2.

Despite these limitations, the HM3 shows promising results. Our case supports its feasibility in children. Its implantation should be investigated more in children over 20 kg and 1.2 cm^2.

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Compliance with Ethical Standard

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval There is no research involving this patient.

Informed Consent The parents signed an informed consent form.

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