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Pediatric Application of the Thoratec CentriMag BiVAD as a Bridge to Heart Transplantation

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The Thoratec CentriMag ventricular assist device (VAD) (Thoratec Corporation Pleasanton, Calif) (Figure 1) is a centrifugal pump designed for extracorporeal support that operates without mechanical bearings or seals. Although extracorporeal membrane oxygenation (ECMO) provides cardiac and respiratory support in a rapid manner for the pediatric patient population, it offers only short-term support with an increase in complications beyond the second week. The CentriMag system has advantages over other systems: the pumps have a low priming volume and low requirements for heparin and hemolysis. We report three successful applications of the CentriMag BiVAD as a bridge to pediatric heart transplantation.

CLINICAL SUMMARIES

PATIENT 1. A 7-year-old previously healthy boy with a 10-day history of abdominal symptoms was brought to the emergency department initially stable, but his condition deteriorated and later necessitated intubation and full cardiac support; his oxygen saturation decreased to 40%. Echocardiographic analysis revealed severely decreased left ventricular function. The heart arrested in the operating room before incision and cardiopulmonary bypass was instituted as an emergency measure. A malleable 28F lighthouse tip

FIGURE 1. CentriMag pump.

cannula (Medtronic, Inc, Minneapolis, Minn) was placed through an incision along the costal margin at a point just inferior to the approximate site of the left ventricular apex. Two concentric purse-string sutures of 3-0 Prolene polypropylene (Ethicon, Inc, Somerville, NJ) supported with bovine pericardial pledgets were placed around the left ventricular apex, and the inflow cannula was placed into the left ventricle. Two 14F Biomedicus cannulas (Biomedicus, Inc, Eden Prairie, Minn) were similarly placed through two incisions along the epigastrium and inserted into the ascending aorta and main pulmonary artery. A 24F malleable lighthouse tip cannula was placed through an incision along the right thoracic wall, and the inflow cannula was placed into the right atrium, directed toward the inferior vena cava. Heparin was started at 24 hours to maintain an activated clotting time of 160 to 180 seconds. Because of pulmonary edema and desaturation, an oxygenator was inserted in-line with the right VAD outflow and was removed after 24 hours once his

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TABLE 1. Clinical summary of the 3 patients

	Patient 1	Patient 2	Patient 3
Body weight (kg)	32	39.8	10.2
LVAD flow (mL/min)	1.9–2.1	3.0–3.1	0.9–1.0
RVAD flow (mL/min)	1.9–2.1	3.0–3.1	0.8–1.0
Cannulas			
LVAD inflow	28F malleable lighthouse tip	28F malleable lighthouse tip	22F malleable lighthouse tip
LVAD outflow	14F Biomedicus	14F Biomedicus	12F Biomedicus
RVAD inflow	24F malleable lighthouse tip	28F malleable lighthouse tip	22F malleable lighthouse tip
RVAD outflow	14F Biomedicus	14F Biomedicus	12F Biomedicus
Transplantation	4 d	3 d	8 h
Outcome	Alive	Alive	Alive

oxygenation had improved with diuresis. He underwent successful heart transplantation 4 days later.

PATIENT 2. A 10-year-old boy with history of dilated cardiomyopathy underwent CentriMag BiVAD implantation and successful heart transplantation 3 days later.

PATIENT 3. A 3-year-old boy with a history of hereditary cardiomyopathy underwent CentriMag BiVAD implantation. At 24 hours postoperatively he was noted to have a small amount of thrombus in the inflow tubing to the device and thus had his left-sided pump exchanged at the bedside. He underwent successful transplantation 8 hours later.

Table 1 shows the clinical summary of the patients.

DISCUSSION

Although ECMO is still the most common form of mechanical support used for infants and young children, data from several institutions suggest ECMO is effective in bridging only half of the eligible children to heart transplantation.^{1–3} Complications such as multiorgan failure, sepsis, and thromboembolism continue to limit ECMO survival to 3 or 4 weeks. The CentriMag BiVAD is technically easy to implant, uses any commercially available inflow or outflow cannulas, and flows between 200 mL/min and 8 L/min. The pump also allows both the potential for extubation and the possibility of including an oxygenator in-line with the right-sided device if necessary, as in our first case.

We have noted several salient points when implanting the CentriMag VAD in children as opposed to adults. First, because of the often very lateral location of the left ventricular apex and the acute angle of the costal margin in children, it is most useful to insert the inflow cannulas through the intercostal spaces with a short subcutaneous tunnel.

Second, because the hearts of these children seem to dilate disproportionately to the size of the great vessels, often the outflow cannulas must traverse a broad angle (and long distance) over the shoulder of the right ventricle before being inserted into the great vessels (which are small) at a nearly 90° angle. It is therefore important not to insert the cannula too far, inasmuch as it will abut the back wall of the great vessel and cause outflow resistance.

Finally, because of the lower flows required with smaller children, an aggressive anticoagulation scheme is suggested, with the commencement of heparin therapy soon after the implantation. Additionally, the use of heparin-coated connectors and tapered tubing, while untested, seems intuitively logical. We also run below full flow in smaller patients so as to decrease the likelihood of obliteration of the left ventricular cavity and air entrainment.

CONCLUSION

We report the successful use of the CentriMag BiVAD in 3 children bridged to transplantation. This clinical indication awaits further application in this age group to better define the possibility of longer term support.

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