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Case Reports

The Thoratec® CentriMag® for Pediatric Right Ventricular Failure

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Abstract: Acute right ventricular failure post heart transplantation in the pediatric population has not been well documented. Treatment using medical therapies including inotropes and nitric oxide are often inefficient for pediatric patients. Extracorporeal membrane oxygenation has been traditionally used in children until a long-term decision can be made. As a result of the emergence of smaller assist devices, pediatric practitioners now have more options available to treat this patient population. We describe the successful use of the Thoratec® CentriMag® in a pediatric patient posttransplantation with acute right ventricular failure. **Keywords:** pediatric heart failure, pediatric transplantation, ventricular assist device, anticoagulation, cardiopulmonary bypass equipment, cardiomyopathy. *JECT. 2013;45:133–135*

The Thoratec® CentriMag® and PediMag® (Thoratec Corporation, Pleasanton, CA) blood pumps provide an option available to physicians treating pediatric patients with ventricular failure. These magnetically levitated centrifugal pumps offer low prime volumes, minimal hemolysis, and are approved by the Food and Drug Administration for 30 days' use. However, these devices carry inherent risk with regard to their need for concomitant anticoagulation management. We describe the decision process, anticoagulation regimen, and management of a pediatric patient at the Medical University of South Carolina post-heart transplantation with acute right ventricular failure.

DESCRIPTION

We present a 13-year-old boy (39.7 kg, 145 cm, 1.27 m^2) with a history of hypoplastic right heart syndrome, multiple atrial septal defects (ASDs) with endocardial fibroelastosis, and progressive ventricular dysfunction. At 2 years of age, the patient underwent device closure of a smaller ASD; at 5 years of age, he underwent a bidirectional glenn operation for palliation of a progressively dysfunctional right ventricle. At 7 years of age, he underwent device closure of a residual secundum ASD. He developed progressive left heart systolic and diastolic dysfunction. The patient was listed for heart transplantation with milrinone-dependent (.5 μg/kg/min) restrictive cardiomyopathy. When a donor organ became available, the patient underwent a cardiac transplantation.

Postoperative transesophageal echocardiogram (TEE) showed mildly depressed right ventricular (RV) function and mild tricuspid regurgitation (TR) with a low velocity jet. Before leaving the operating room, central venous pressure (CVP) was 12–15 mmHg. Within the first few hours in the pediatric cardiac intensive care unit (PCICU), the CVP rose to the mid-20s. A repeat echocardiogram (ECHO) in the PCICU showed worsening TR. Over the next few days, the patient developed RV dysfunction with free TR. He developed significant renal dysfunction and had increasing inotropic requirements. An endomyocardial biopsy ruled out rejection.

On postoperative Day (POD) 4, the patient had worsening right ventricular dysfunction and dilation with

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severe TR and escalation of inotropic support (epinephrine from .01 μg/kg/min to .02 μg/kg/min, dopamine from 5 μg/kg/min to 10 μg/kg/min, milrinone from .5 μg/kg/min to 1 μg/kg/min). With a CVP in the mid-20s, the decision was made to place a RV support device. The patient was brought to the operating room for cannulation and initiation of the CentriMag®. Cannulation pursestring sutures were placed in the RV outflow tract and the right atrial appendage. Heparin was administered (100 IU/kg) and a 7-Fr Sarns™ Soft-Flow® (Terumo Cardiovascular Systems Corporation, Ann Arbor, MI) aortic cannula was placed in the RV outflow tract under TEE guidance. A 28-Fr metal-tipped, right-angle DLP® (Medtronic, Inc., Minneapolis, MN) cannula was placed in the right atrial appendage. The ventricular assist device (VAD) circuit consisted of 3/8-inch SMARxT-coated (Sorin Group USA, Inc., Arvada, CO) tubing from the right atrial cannula to the inlet of the CentriMag® pump and 3/8-inch coated tubing from the outlet to the RV outflow tract (Figure 1). A bridge was in place between the inflow and outflow lines to allow for recirculation during trial-off periods. Flow was started initially at 1 L/min and was gradually increased to 3.3 L/min (2.6 L/min/m^2). At 2.6 L/min/m^2, TEE demonstrated excelled RV decompression and moderate reduction of TR. Fifteen minutes after the initiation of the VAD, coagulation laboratory values were sent (Table 1). The sternum was then closed and the patient was transferred back to the PCICU.

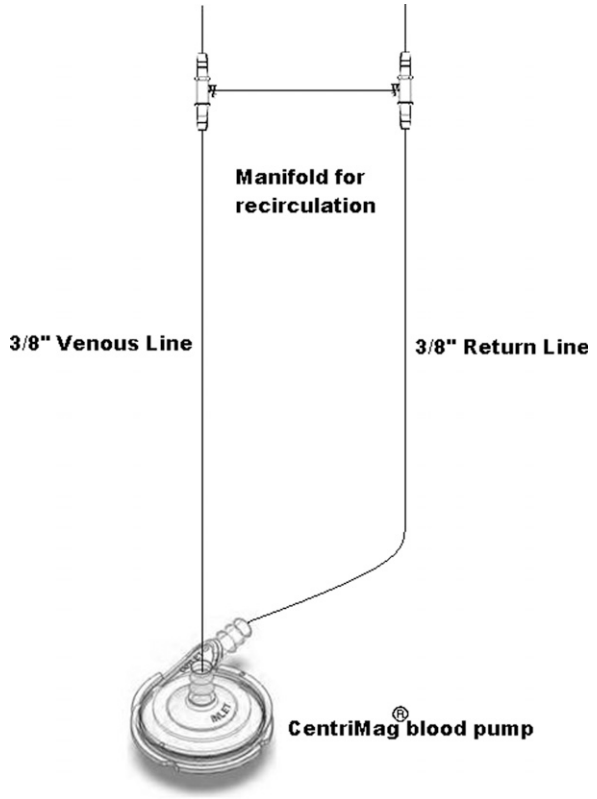

Figure 1. CentriMag® circuit.

Table 1. Coagulation profile posttransplant and post-VAD initiation.

Laboratory Results	Posttransplant	Post-VAD Initiation
ACT (seconds)	134	158
PT (seconds)	18.3	Not drawn
INR	1.51	Not drawn
aPTT (seconds)	36.1	130
Fibrinogen (mg/dL)	321	239
Platelet (K/mm^3)	110	137
Xa (IU/mL)	Not drawn	.51

VAD, vascular assist device; ACT, activated clotting time; PT, prothrombin time; INR, international normalized ratio; aPTT, activated partial thromboplastin time; Xa, unfractionated antifactor Xa.

An institutional anticoagulation management protocol was activated before initiation of the CentriMag®. The protocol states to maintain an activated partial thromboplastin time (aPTT) of 60–80 seconds unless otherwise ordered. As a result of the increased chest tube output, it was determined that lower aPTTs would be acceptable in the immediate postoperative period, providing that no visible clot is evident in the circuit. The protocol was then changed to accept aPTTs of 35–50 seconds for the immediate postoperative period, which allowed for delayed initiation of the heparin drip. During VAD Days 1 and 2 (PODs 4 and 5), aPTTs ranged from 30 to 38 seconds and unfractionated antifactor Xa was initially .51 IU/mL and decreased to .1 IU/mL. As a result of decreased chest tube output and the coagulation panel results, heparin was started on VAD Day 2 (POD 6) at 15 U/kg/h and remained between 15 and 20 U/kg/h during mechanical support. Coagulation minimum and maximum ranges are presented in Table 2. Antithrombin levels were drawn at baseline and for 2 days post-VAD placement to ensure adequate levels for heparinization.

On VAD Day 1 (POD 4), the TR decreased with a decrease in the size of the tricuspid orifice. Additionally, the septal wall motion improved, whereas the right ventricle remained severely dysfunctional. On VAD Day 2 (POD 5),

Table 2. Coagulation profile during mechanical support.

Laboratory Results	Minimum–Maximum
PT (seconds)	17.6–18.6
INR	1.35–1.55
aPTT (seconds)	30.2–90.8
Hematocrit (%)	25.5–39.1
Fibrinogen (mg/dL)	214–271
AT III (%)	60–74
Platelet (K/mm^3)	77–137

PT, prothrombin time; INR, international normalized ratio; aPTT, activated partial thromboplastin time; AT, antithrombin III.

the RV free wall and apex motion increased. The right ventricle continued to improve on a daily basis. On VAD Day 5 (POD 8), the RV had only minimally decreased function with mild TR.

Flow rates were maintained at 3.6 L/min (2.6 L/min/m^2) until weaning mechanical support, which began on VAD Day 5 (POD 8). Flows were decreased to 1.85 L/min and the heparin drip was lowered from 20 U/kg/h to 18 U/kg/h (as a result of elevated aPTT values) and remained there until termination of VAD support. An ECHO performed while on minimal support revealed identical findings like during full support and no appreciable change in TR. VAD support was decreased to 1.2 L/min on Day 6 (POD 9) and support was discontinued on Day 7 (POD 10). The patient was taken to the operating room for cannulae removal. The cannulae were clamped without change in RV function or TR by TEE. The sternum was approximated without hemodynamic changes. The patient was then transported back to the PCICU.

DISCUSSION

The use of VADs in children has been limited in the past as a result of the small circulatory system of the pediatric patient as well as lack of equipment available for support. Traditionally extracorporeal membrane oxygenation (ECMO) has been the primary option for this patient population until the recent introduction of pediatric mechanical circulatory support devices. There are still only a few published studies using these devices in the pediatric population and of those, to our knowledge, none were in a pediatric patient posttransplantation for acute right heart failure (1–4). Studies have been conducted in the adult population for post-cardiopulmonary bypass cardiogenic shock, showing the benefit of the CentriMag® for short-term mechanical support (5–8). According to a study conducted by Hernandez et al. (9) using data from the Society of Thoracic Surgeons, the rates of survival to hospital discharge have improved dramatically. Our institution used the CentriMag® for posttransplant acute right heart failure in a pediatric patient for 7 days without complications. Acute right heart failure posttransplant has traditionally been managed with ECMO in pediatric patients because this has been the only tool available. The use of a RV assist device, without an oxygenator, allowed for less anticoagulation, potentially decreasing the amount of bleeding in this patient. VADs may allow for earlier extubation, improved enteral nutrition, and earlier physical therapy (10,11).

CentriMag® for short-term use, with a minimized heparin loading dose, may be beneficial in managing postoperative bleeding. Some studies report the use of 300 U/kg of heparin for loading doses; however, we load our patients with 100 U/kg (1). If there is not an oxygenator in-line, we feel 100 U/kg of heparin is an effective way to anticoagulate without the increased risk for hemorrhage. We report the use of a CentriMag® device with low-dose heparin therapy without device failure or thrombotic events. Anticoagulation is a fine balance in this patient population and therefore must be managed thoughtfully (12).

Our pediatric patient showed a clear benefit from RV support with the CentriMag®. His CVP returned to normal, allowing for improved renal perfusion. His TR resolved and his RV function improved. He did not develop complications. Using low-dose heparin therapy and maintaining an aPTT between 60 and 80 seconds was successful for this patient. In conclusion, our experience illustrates that it is possible to support a patient with RV failure using the CentriMag®. This mechanism warrants further investigation to the safety and effectiveness in treating patients with RV failure.

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