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Mechanical circulatory support using modified TandemHeart ventricular assist device in neonates with CHD

Shamsur Chowdhury[1], Tanya Chadha[1], Mark Fafard[2] and Michael Shillingford[3]

[1]Pediatric Cardiac Intensive Care, Wolfson Children's Hospital, Jacksonville, FL, USA, [2]Baptist Health Research Institute, Jacksonville, FL, USA and [3]Pediatric Cardiothoracic Surgery, Wolfson Children's Hospital, Jacksonville, FL, USA

Brief Report

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Author for correspondence:
S. Chowdhury, MD, Division of Pediatric Critical Care Medicine, Wolfson Children's Hospital, 800 Prudential Dr, Jacksonville 32207, FL, USA. Tel: +904 202 8758; Fax: +904 306 9884; E-mail: Shamsur.chowdhury@jax.ufl.edu

Abstract

TandemHeart, an adult ventricular assist device, is also being used in children for mechanical circulatory support. In this case series, we describe our experience using TandemHeart ventricular assist device with a modified circuit to provide mechanical circulatory support in three neonates for multiple indications. TandemHeart ventricular assist device with a modified circuit can be used successfully to provide extracorporeal support to neonates with complex CHD.

Mechanical circulatory support is an invaluable tool in the management of post-cardiotomy heart failure in infants and children with CHD.[1] Extracorporeal membrane oxygenation has been the mode of choice for circulatory support in children after cardiac surgery. However, its application is associated with more bleeding and thrombotic complications in children with CHD, and a survival rate as low as 40% in neonates.[2–4] Ventricular assist devices are increasingly being used for short-term extracorporeal support. However, most ventricular assist devices do not support oxygenation or lower flow rates in younger children.[5]

The TandemHeart (CardiacAssist, Pittsburgh, Pennsylvania, United States of America) ventricular assist device is a centrifugal pump traditionally used in adults with heart failure that requires a minimum revolutions per minute of 3500 or a minimum flow of 1 L/minute. In paediatrics, several reported circuit modifications provide lower flow including recirculation shunt, flow occlusion clamps, and, in some cases, an oxygenator.[6,7] Although there are reports of successful TandemHeart ventricular assist device support using a modified circuit in children,[6–8] there is a lack of data on its application in neonates and infants. We previously published our experience using TandemHeart ventricular assist device with a modified circuit in a 2-month-old infant with single-ventricle physiology.[9] We now describe our experience using TandemHeart ventricular assist device in three neonates with complex CHD to provide circulatory and oxygenation support.

Patients and methods

We modified the TandemHeart ventricular assist device circuit by introducing an oxygenator (Quadrox; Maquet, Rastatt, Germany) on the outflow limb, a haemoconcentrator (Sorin Inc., Arvada, Colorado, United States of America) to the pre-oxygenator tubing, and gate clamps in post-oxygenator limb. This setup provides oxygenation, the ability to maintain fluid balance, and acts as a recirculation shunt enabling lower flow to infants.

Patients were cannulated centrally with venous cannula in the right atrium – or common atrium in single ventricle – and arterial cannula in the ascending aorta. Heparin anticoagulation was initiated 6–24 hours after ventricular assist device implantation in the operating room depending on chest tube drainage and 3–6 hours of implantation in the cardiovascular ICU unless there were active bleeding. Anti-Xa levels were checked primarily to monitor heparin anti-coagulation (goal: 0.3–0.5 IU/ml) supplemented by checking more frequent activated clotting time (goal: 150–170 seconds). Antithrombin 3 concentrates were administered for level <70%. Ultrafiltration was used early on and was titrated according to desired fluid balance, urine output, and haemodynamics status of the patient.

Patient 1

A full-term male neonate (weight – 2.9 kg, body surface area (BSA) – 0.2 m^2) with prenatal diagnosis of hypoplastic left heart syndrome underwent Norwood with Sano at 12 days of life. The immediate post-operative course was complicated by hypoxia and a brief cardiac arrest with successful resuscitation. Diagnostic cardiac catheterisation and angiography excluded Sano shunt thrombosis or arch obstruction. On post-operative day 2, the patient again acutely

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decompensated with severe hypoxia and low cardiac output state unresponsive to inotropic support, inhaled nitric oxide, and Flolan (epoprostenol). The patient was placed on TandemHeart ventricular assist device through central cannulation (common atrium, aorta) with a flow between 100 and 120 ml/kg/minute. The patient's haemodynamics and oxygenation improved immediately, inotropic support was weaned off, and ventilator was weaned to rest settings. After improvement in cardiorespiratory function and adequate fluid removal, patient was weaned off TandemHeart support on post-operative day 7. The chest was closed on day 10 followed by successful extubation on post-operative day 21. The patient was discharged home on post-operative day 39 with both oral and nasogastric tube feeding. Currently, the patient is home, stable, and awaiting bidirectional Glenn procedure.

Patient 2

An 11-day-old full-term male neonate (weight – 3.3 kg; BSA – 0.22 m^2) with a diagnosis of congenitally corrected transposition of great arteries and pulmonary stenosis underwent a 3.5-mm modified Blalock-Taussig (BT)-shunt placement. Immediate post-operative course was complicated by severe hypoxia and low cardiac output state unresponsive to ventilation, inhaled nitric oxide, and inotropic drugs. The patient was placed on mechanical circulatory support using BioMedicus cardiopulmonary support pump (Medtronic, Minneapolis, Minnesota, United States of America). Cardiac catheterisation and angiography showed a patent BT shunt but a narrowed pulmonary artery branch at the shunt anastomosis site. Following a pulmonary arterioplasty, the patient was successfully weaned off the cardiopulmonary support pump. However, on post-operative day 2, the patient decompensated again with acute severe hypoxia and low cardiac output state. He was placed on TandemHeart ventricular assist device support via central cannulation (right atrium, aorta) with a flow between 100 and 120 ml/kg. Patient's oxygenation and haemodynamics improved and he was taken off ventricular assist device support on post-operative day 7. The patient was extubated on post-operative day 15 and was discharged home on post-operative day 28.

Patient 3

A full-term male infant (weight – 3.9 kg, BSA – 0.24 m^2) with a prenatal diagnosis of *d*-transposition of great arteries underwent arterial switch operation at 2 weeks of life. He developed acute left ventricular failure and severe hypotension upon separation from cardiopulmonary bypass. The patient was emergently placed on TandemHeart ventricular assist device through central cannulation with a flow of 110–120 ml/kg/minute. His haemodynamics and left ventricle function improved significantly and was weaned off ventricular assist device on post-operative day 3. The chest was closed on post-operative day 5 followed by extubation on the same day. The patient's remaining inpatient course was uneventful and was discharged home on post-operative day 14.

Discussion

Mechanical circulatory support for neonates with CHD is an ongoing challenge. Common indications for mechanical circulatory support include failure to wean from cardiopulmonary bypass, severe low cardiac output state, cardiac arrest, pulmonary hypertension, and bridge to transplantation.[1,2] To date, traditional extracorporeal membrane oxygenation has been the mode of choice for short-term circulatory support in children. However, neonates with CHD are the highest-risk paediatric population for complications associated with traditional extracorporeal membrane oxygenation support.[4]

There are reports of successful TandemHeart ventricular assist device support with modified circuit for mechanical circulatory support in children with CHD for multiple indications including heart failure and bridge-to-transplant.[6–8] Our modification includes placing an oxygenator and a haemoconcentrator unit within the circuit, a setup that would modulate lower flow to younger children and provide cardiac, pulmonary, and renal support.

Extracorporeal support using TandemHeart ventricular assist device requires less personnel at bedside (one nurse: one patient), and uses single inventory across all age groups that can lower the overhead costs, unlike other modes of extracorporeal support.

To our knowledge, this case series includes the smallest and youngest patients supported on the TandemHeart ventricular assist device. TandemHeart ventricular assist device with circuit modification can safely and effectively provide mechanical circulatory support to neonates with complex CHD complicated by pre- and post-operative heart failure. The TandemHeart ventricular assist device is easy to deploy, is cost-effective, and can be an attractive mode of extracorporeal support in children including neonates.

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Conflicts of Interest. None.

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