Cardiology in the Young

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Intravenous prostacyclins for right ventricular failure following left ventricular assist device in paediatric heart failure

Laura J. Radel, Mehreen Iqbal and Megan Griffiths

Division of Cardiology, Department of Paediatrics, University of Texas Southwestern, Dallas, TX, USA

Brief Report

Cite this article: Radel LJ, Iqbal M, and Griffiths M (2023) Intravenous prostacyclins for right ventricular failure following left ventricular assist device in paediatric heart failure. *Cardiology in the Young* **33**: 2422–2424. doi: 10.1017/S1047951123001725

Received: 27 March 2023
Revised: 7 May 2023
Accepted: 4 June 2023
First published online: 29 June 2023

Keywords:
Left ventricular assist device; right heart failure; prostacyclin; paediatric heart failure; pulmonary hypertension

Corresponding author:
M. Griffiths;
Email: megan.griffiths@utsouthwestern.edu

Abstract

Right ventricular failure after placement of left ventricular assist device in paediatric heart failure is associated with increased mortality. We report successful use of intravenous prostacyclin for right ventricular support and pulmonary hypertension after initiation of left ventricular assist device support. This suggests that intravenous prostacyclins may be an important therapy in right ventricular failure following ventricular assist device implantation.

Left ventricular assist device use is increasingly utilised in advanced paediatric heart failure. Right ventricular failure following left ventricular assist device is common, complicating approximately half of all paediatric device implants. Right ventricular failure is associated with three to six times the risk of mortality after ventricular assist device implantation.[1] This highlights the importance of effective treatment of right ventricular failure after left ventricular assist device implantation. We describe two cases of successful use of intravenous prostacyclin therapy for right ventricular support after paediatric left ventricular assist device implantation.

Case 1

Four-year-old female with history of trisomy 21 and partial atrioventricular canal defect status post-repair complicated by left ventricular haematoma and subsequent left ventricular failure refractory to medical therapy. Echocardiogram demonstrated severe biventricular dysfunction with severe right and left atrioventricular valve regurgitation. Cardiac catheterisation demonstrated left atrial hypertension and pulmonary vascular resistance of 5.3 WU/m^2 (Table 1). She was subsequently cannulated to left ventricular assist device via 6 mm Berlin Heart cannulae to PediMag device in a left ventricular apex to aorta configuration. Intra-operative transesophageal echocardiogram after cannulation demonstrated moderately diminished right ventricular function with moderate right atrioventricular valve regurgitation. She developed persistent low-flow alarms on the device with high central venous pressure in the first 24 hours post-op due to low preload from right ventricular failure despite support with inhaled nitric oxide up to 40 ppm and milrinone. She was started on intravenous epoprostenol at 2 ng/kg/min with rapid uptitration by 2 ng/kg/min every 15–30 minutes to a goal dose of 10 ng/kg/min resulting in rapid improvement in haemodynamics, increased cardiac output and reduction in right atrial pressures (Fig 1). The dose was subsequently increased to 14 ng/kg/min over the following 48 hours to achieve goal of right atrial pressures and ventricular assist device flows. This patient was successfully transitioned to targeted pulmonary hypertension therapy for pulmonary vascular remodelling and ongoing right ventricular support.

Case 2

Eleven-month-old male with severe aortic valve stenosis, moderate aortic insufficiency, and severely stenotic dysplastic mitral valve developed low cardiac output syndrome and ST segment changes suggestive of ischaemia during diagnostic cardiac catheterisation. Right ventricular peak pressure was 80% systemic, and pulmonary vascular resistance was 7.9 WU/m^2 (Table 1). He was transferred to the cardiac ICU for ongoing coronary insufficiency and low cardiac output requiring medical paralysis and sedation. He was taken to the operating room for elective left ventricular assist device cannulation with 6 mm Berlin Heart cannulae to PediMag device in a left atrium (intra-atrial tunnel across the right atrium using a 10 mm polytetrafluoroethylene graft) to aorta position (anastomosed to 6 mm Peca ExGraft). Milrinone and inhaled nitric oxide at 20 ppm were initiated intra-operatively for right ventricular support. Post-operatively, he

Table 1. Haemodynamics before/after LVAD and prostacyclin initiation.

Case 1	Pre-LVAD/prostacyclin	Post-LVAD/prostacyclin
Mean right atrial pressure (mmHg)	7	
Pulmonary artery pressure (mmHg)	45/20, mean 31	
Mean left atrial pressure (mmHg)	13	
Transpulmonary gradient (mmHg)	18	
Cardiac index (L/min/m^2)	2.6	
Pulmonary vascular resistance index (WUi)	5.3	
Case 2		
Mean right atrial pressure (mmHg)	9	13
Pulmonary artery pressure (mmHg)	70/33, mean 47	22/15, mean 17
Mean left atrial pressure (mmHg)	27	12
Transpulmonary gradient (mmHg)	20	5
Cardiac index (L/min/m^2)	2.5	4.3
Pulmonary vascular resistance index (WUi)	7.9	1.4

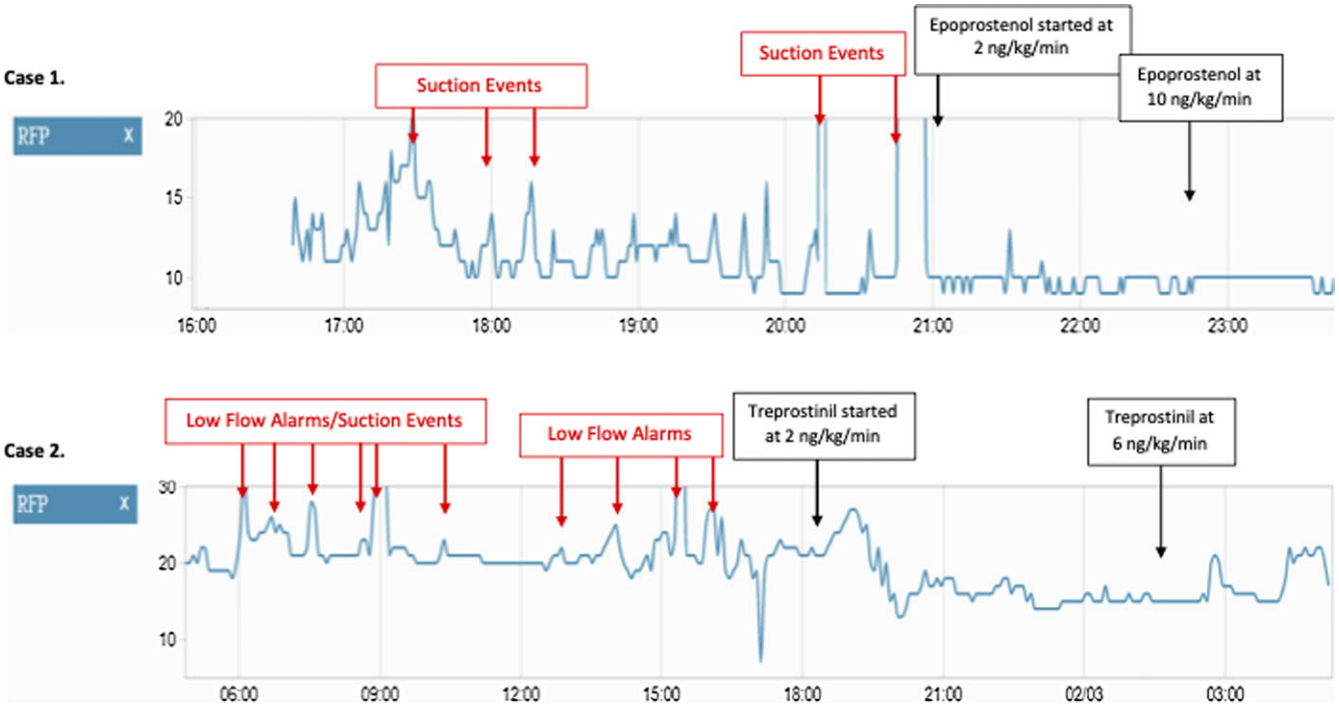

Figure 1. Etiometry recording of central venous pressure prior to and immediately after initiation of IV prostacyclin. Times of IV prostacyclin inititation and titration are labeled. Times of LVAD low flow alarms and suction events are labeled.
RFP: Right atrial filling pressure

developed signs of right ventricular failure with high right atrial pressure and recurrent left ventricular assist device low-flow alarms. On initiation of intravenous treprostinil at 2 ng/kg/min (increased by 2 ng/kg/min every 4 hours to goal dose of 24 ng/kg/min based on hemodynamic response), right atrial pressure decreased and left ventricular assist device speed was able to be increased to achieve adequate systemic perfusion (Fig 1). This patient was transitioned to targeted pulmonary hypertension therapy for ongoing right ventricular support and pulmonary hypertension management.

Discussion

Right ventricular failure commonly occurs after left ventricular assist device, especially in patients with pre-operative pulmonary vascular disease. While a left ventricular assist device acutely unloads the right ventricle, pulmonary vascular remodelling occurs over a more prolonged duration, during which patients are at high risk for right ventricular failure and low cardiac output with higher risk of mortality. By activation of pulmonary endothelial cell G-protein receptors, prostacyclin leads to increased intra-cellular cyclic adenosine monophosphate and activation of protein kinase

https://doi.org/10.1017/S1047951123001725 Published online by Cambridge University Press

A, which increases smooth muscle relaxation.[2] The resulting pulmonary vasodilation and reduced pulmonary vascular resistance lead to a decrease in the right ventricular afterload,[3] which is analogous to the role of ACEi/ARB/ARNi therapy in left ventricular dysfunction. Epoprostenol causes very rapid pulmonary vasodilation and can be titrated to a goal dose very quickly. Thus, epoprostenol can be an effective rescue agent for right ventricular failure causing haemodynamic compromise after left ventricular assist device, such as in case 1. Treprostinil is a powerful pulmonary vasodilator with a longer half-life, which improves its side effect profile and makes it easier to administer (no risk of crisis during brief pause in medication).

These cases suggest that intravenous prostacyclins may be an effective additive therapy for right ventricular failure after left ventricular assist device placement. Given the high prevalence of right ventricular failure after left ventricular assist device in paediatrics and its strong association with mortality, the success of these two cases highlights the need to study the utilisation and efficacy of prostacyclins systematically and prospectively in a multi-institutional paediatric left ventricular assist device cohort.

Financial support. This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

Competing interests. None.

Ethical standard. Not applicable.

References

1. Simpson KE, Kirklin JK, Cantor RS, et al. Right heart failure with left ventricular assist device implantation in children: an analysis of the pedimacs registry database. J Heart Lung Transplant 2020; 39: 231–240.
2. Avitabile CM, Vorhies EE, Ivy DD. Drug treatment of pulmonary hypertension in children. Paediatr Drugs 2020; 22: 123–147.
3. Kerbaul F, Brimioulle S, Rondelet B, Dewachter C, Hubloue I, Naeije R. How prostacyclin improves cardiac output in right heart failure in conjunction with pulmonary hypertension. Am J Respir Crit Care Med 2007; 175: 846–850.

https://doi.org/10.1017/S1047951123001725 Published online by Cambridge University Press