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Successful experience with Levitronix PediVAS for management of acute heart failure after Fontan surgery

Case Report

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Abstract: An extracorporeal membrane oxygenation was long a golden standard in the pediatric population with acute cardiac failure for short-term mechanical circulatory support. It gives the limited availability of pediatric-sized pumps and the outcomes remain disproportionately poor. The Levitronix PediVAS system (Levitronix LLC, Waltham, MA) offers expanded options for short-term support for this population. We report our experience with the successful use of the PediVAS (left heart bypass) in the 3-year-old male patient as a bridge to recovery after Fontan surgery in acute heart failure. Short-term circulatory support with the Levitronix PediVAS has proven to be a less invasive, safe, and effective for our pediatric patient.

Keywords: *Ventricular assist device • Levitronix PediVAS • Acute cardiac failure • Fontan surgery*

1. Introduction

Extracorporeal membrane oxygenation (ECMO) has long been the only choice for short-term mechanical circulatory support (MCS) in the pediatric patient. This system is well established in the adult population. There is limited availability of pediatric-size pumps and oxigenators as well as the extremely limited time of support that ECMO allows. Poor outcomes are determined and by potentially serious adverse events including neurologic complications, platelet consumption, and hemorrhage [1]. A less invasive choice is the Levitronix device (CentriMag), which is a magnetically levitated centrifugal pump system, having the utility for treating adults and large children (1,500 utilized worldwide). This device can be used as part of an ECMO circuit and to a lesser extent to provide left, right, or biventricular mechanical assistance. The PediVAS (Levitronix LLC, Waltham, MA) is intended for neonates and pediatric patients with flows from 0.3 to 3.0 L/min at rotor speeds up to 5,500 rpm. The pump is capable of functioning for weeks with low hemolysis and minimal thrombus formation [2]. We report a successful application of the Levitronix PediVAS system in the small pediatric patient as a bridge to recovery after Fontan surgery in acute cardiac failure.

2. Materials and methods

A 3-year-old male (13.1 kg, body surface area 0.58 m^2) with congenital heart disease (single ventricle and complete atrioventricular septal defect) presented to our hospital with worsening hypoxemia for third stage – external Fontan operation. He underwent the first stage pulmonary artery narrowing and bidirectional Glenn as the second stage operation in the past. The final stage

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Fontan reconstruction with external conduit and fenestration was performed. Progressing cyanosis, shortness of breath, erythremia (Hemoglobin – 196 g/l) were indications for surgery. Transthoracic echocardiography (TTE) showed preserved heart function. The operation underwent on beating heart and cardiopulmonary bypass time was 96 minutes. On the second postoperative day the patient developed severe heart failure with low cardiac output. A multisystem organ failure started to present. TTE revealed a single ventricle with an ejection fraction of 30%. Mainstay treatment with maximal inotropic support as well peritoneal dialysis was ineffective. It was decided to use a Levitronix PediVAS device for mechanical circulatory support rather then ECMO as we were considering a possibility for long-time heart failure. In this case Levitronix could be used up to 30 days and longer [2,8]. Single ventricle (left heart bypass) support with the PediVAS device was initiated through median resternotomy by placing a 12-French Medtronic DLP® arterial cannula to the ascending aorta and bent angle wire-reinforced 18-French Terumo® venous cannulla to the dome of the common atrium (Figure 1). These cannulae were connected with air-free Levitronix tubes. The chest was closed. An oxygenator was not used. On the initial phase the speed of PediVAS was chosen as a full cardiopulmonary flow speed in the normothermic condition at 1,7 L/min and 4300 rpm. Flows were maintained between 0.3 and 1.7 L/min at 2350-4400 rpm. Dynamics of PediVAS, arterial blood gas and saturation parameters as well dosage of inotropes are showed in Table 1. A right pleural effusion complicated postoperative course. A resternotomy was performed for hematoma evacuation, no major bleeding source was found. Intravenous unfractionated heparin was used for anti-

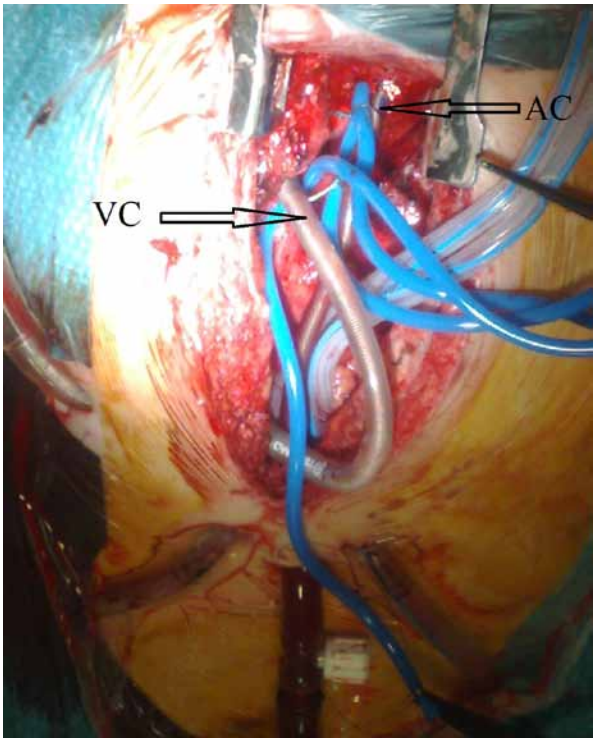

Figure 1. The moment of PediVAS initiation showing arterial cannula inserted into aorta and venous cannulla placed in the dome of common atrium. VA – venous cannula, AC – arterial cannula.

coagulation in sub therapeutic doses due to the risk of bleeding. After 4 days of circulatory support, weaning trials revealed significant recovery of the heart and the Levitronix support system was successfully explanted (Figure 2). The gradually improvement of the patient could be observed and checking laboratory parameters (Table 2). We decided to stop PediVAS support after

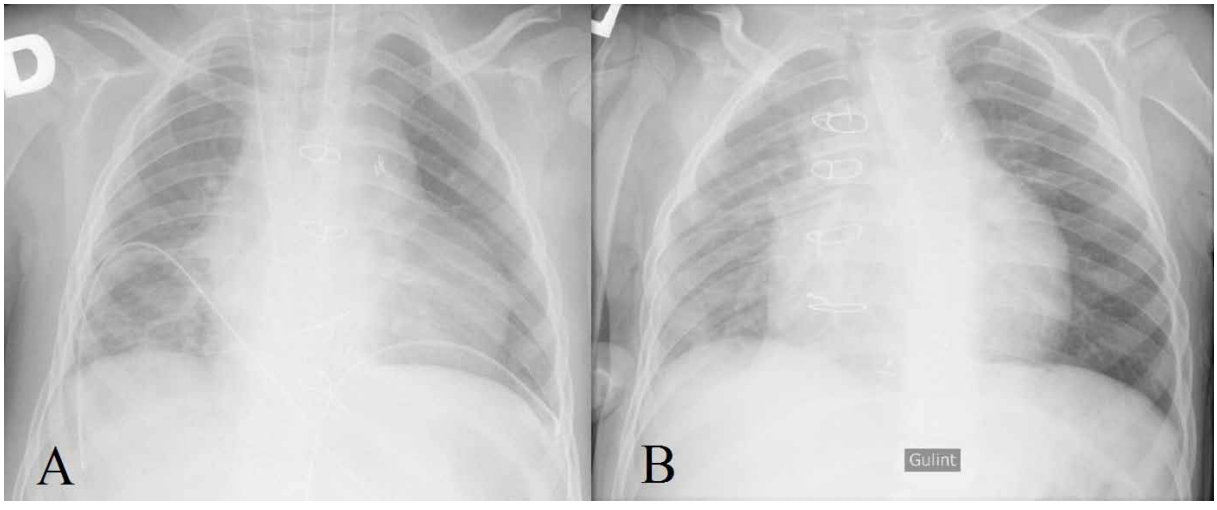

Figure 2. Comparison of chest radiograms: 12 hours before PediVAS pump implementation (A) and after PediVAS pump removal (B). The significant reduction of the size of the heart can be observed in Figure B.

Table 1. Dynamics of PediVAS parameters, dosage of inotropes, arterial blood gas and saturation values in acute phase.

Parameters \ Time	Just after FP	24h after FP	48h after FP (just after VADC)	24h post VADC	48h post VADC	72h after VADC	93h (just before VADD)	24h after VADD	48h after VADD
VAD, l/min.	-	-	1,7	1,7	1,37	1,32	0,3	-	-
RPM	-	-	4300	4350	3750	3700	2350	-	-
t, C	35	36,7	35,7	36,3	36,8	37,1	36,3	38,4	37,4
BP, mmHg	61/36	63/45	78/63	69/64	86/69	82/66	97/65	103/59	92/55
HR, min.	143	166	134	160	127	127	112	153	131
CVP, cmH_2O (FV/IJV)	14/13	14/14	16/15	22/22	14/15	12/20	17/18	15/18	-/13
SO_2,%	83	82	89	76	93	89	94	87	85
pO_2 (ABG), mmHg	53,7	55,5	41,2	46,2	54,8	51,4	52,6	54,5	46,8
pCO_2 (ABG), mmHg	43,9	50,1	43,6	57,1	40,3	42,8	44,6	39,5	37,7
FiO_2, %	60	100	100	80	60	65	50	40	10l mask
$etCO_2$	35	35	28	37	34	32	30	32	-
Dopamin, μg/kg/min	-	5	5	3	2	3	3	2,9	2
Milrinone, μg/kg/min	-	0,4	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Adrenalin, μg/kg/min	0,07	0,15	0,16	0,05	0,03	0,02	0,008	-	-
Lactate, mmol/l	3,1	2,3	3	1,6	2,4	2,1	1,9	2	1,7

VAD – ventricular assist device, RPM – revolutions per minute, BP – blood pressure, HR – heart rate, CVP – central venous pressure, FV – femoral vein, IJV – internal jugular vein, ABG – arterial blood gas, $ETCO_2$ – end tital CO_2, FP – Fontan procedure, VADC – VAD connection, VADD – VAD disconnection

Table 2. The laboratory parameters during PediVas support. Gradually improvement of the white blood cells, urea, creatine, protein, albumin, C-reactive protein and troponin I can be observed.

	day 1	day 2	day 3	day 4
White blood cells, 10^9/l	23,88	13,23	12,38	15,57
Hemoglobin, g/l	141	141	140,1	141,6
Platelets, 10^9/l	50	116	153,9	83,3
Urea, mmol/l	14,3	9,9	6,6	4,2
Creatinine, μmol/l	68	56	49	42
Total serum protein, g/l	39,7	49,6	-	61,7
Albumin, g/l	19,6	29	-	45,7
C-reactive protein, mg/l	29,8	22,4	-	1,99
Troponine I, μg/l	2,902	2,001	-	0,302
Activated clotting time, s	163	135	146	145

the patient was hemodinamically stable for 2 hours on very low device flow (0,3 l/min) and TTE showed stable ventricle function with an ejection fraction of 40%. Chest drains were removed on 29th day and the patient was discharged home on the 35th postoperative day. At one-year follow-up TTE showed a single ventricle ejection fraction of 55%, patent fenestration, and trivial regurgitation of the common atrioventricular valve.

3. Discussion

Percutaneous assist devices, surgically implanted ventricular assist devices (VAD), or ECMO are the options currently available for circulatory support. However, there are no precise gudelines how and which device to implement in the discussed case. Furthermore, ECMO has high waitlist mortality and a reported survival to hospital discharge of less than 50% [3,4]. The use of MCS devices in the pediatric population for short-term bridge to recovery and decision for long-term bridge to transplantation has been a significant challenge. The Levitronix CentriMag has proven to be an extremely versatile pump in the adult population as a bridge to recovery for postcardiotomy shock with minimal neurologic issues or device-related complications [5]. Recent reports describe the successful application of the Levitronix as a bridge to decision after postcardiotomy ventricular failure and as a bridge to recovery after heart transplantation in “grownups” pediatric patients [1,6,7]. We report the versatile and effective role the Levitronix PediVAS played in our failing Fontan patient as a postoperative bridge for recovery. In addition, no oxygenator was needed. Furthermore, the use of the Levitronix PediVAS as a bridge to recovery after postcardiotomy acute ventricular failure has also not been previously reported.

The proper timing of establishing mechanical circulatory support is a crucial step and one that can greatly affect survival outcomes. No established criteria exist to date [8]. With the ongoing development of pediatric VADs, the face of mechanical circulatory support is changing quickly. This would give hope that VADs could be used for longer periods with less morbidity in pediatric patients with acute myocardial failure as a bridge to recovery or decision.

4. Conclusion

We report a unique successful application of emergency short-term support with the Levitronix PediVAS system in one complex pediatric patient with severe heart failure after Fontan operation. Implementation of this safe and versatile centrifugal pump provided short-term support with minimal complications in 3-year-old male pediatric patient as a bridge to recovery.

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