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Use of an Intrapericardial Continuous Flow Ventricular Assist Device in a 4-Year-Old Child Weighing 12 Kilograms

Korhan Erkanlı, MD,[1] Mehmet Kaya, MD,[1] Murat Avşar, MD,[2] İhsan Bakır, MD[1]

[1]Department of Cardiovascular Surgery, Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital, Istanbul, Turkey; [2]Department of Cardiothoracic, Transplantation and Vascular Surgery, Hannover Medical School, Hannover, Germany

ABSTRACT

Ventricular assist devices are implanted in patients with intractable heart failure as a bridge to cardiac transplantation to support the circulatory system mechanically. We present a report of a continuous flow ventricular assist device successfully placed as a bridge to transplantation in the intrapericardium of a petite-sized child with a BSA of 0.56 m^2. Not only is the use of an intrapericardial, continuous-flow, centrifugal pump feasible for destination therapy, but also for low-weight pediatric patients with end-stage heart failure as a bridge to transplantation when there is chronic shortage of donor organs for heart transplantation. Consequently, the HeartWare system has been implanted in smaller patients with acceptable results, and this patient may be the youngest ever reported.

INTRODUCTION

For the past 10 years, ventricular assist devices (VADs) have been commonly implanted to provide durable mechanical circulatory support in children with apparent intractable heart failure as a bridge to cardiac transplantation [Cabrera 2013]. Paracorporeal systems are routinely used in children. However, limited options exist for intracorporeal technologies, especially in the low-weight pediatric population [Miera 2011; Padalino 2014].

CASE REPORT

A 4-year-old boy presented to the pediatric cardiologist with the complaint of vomiting. Echocardiogram on admission was notable for a dilated, hypertrophied left ventricle (LV) with a left-ventricular ejection fraction (EF) of 15%. Fractional shortening was 6%. LV end diastolic diameter was 69 mm (z-score +8 and +9); LV end systolic diameter was 64 mm (z-score + 9.3). Right heart functions and diameters including right ventricular outflow tract were normal by echocardiographic views. The patient weighed 12 kg and was 95 cm in height. His body mass index was 19.3 kg/m^2 and body surface area (BSA) was 0.56 m^2. He was in the 3rd-10th percentile for weight and 50-75th percentile for height.

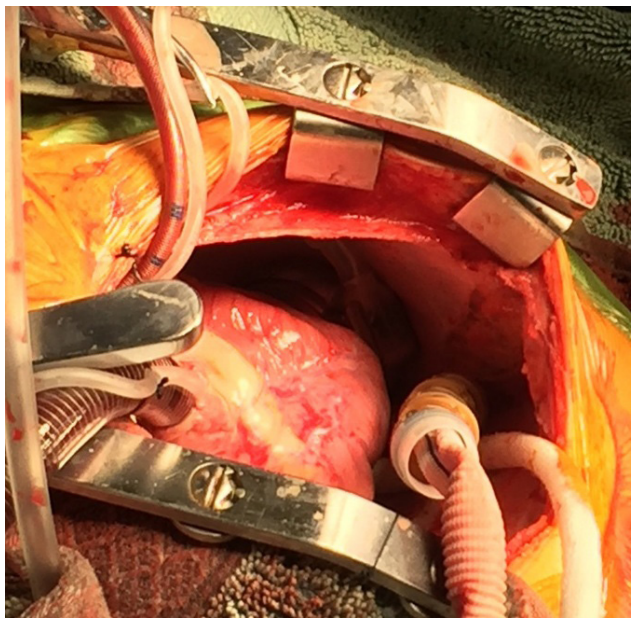

Figure 1. Locally resected area of the diaphragm.

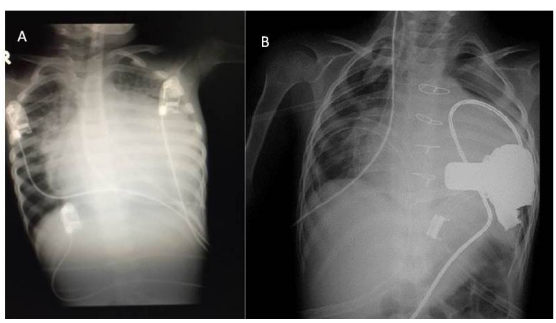

Figure 2. A, Preoperative chest x-ray of patient. B, Chest x-ray of patient with the implanted HeartWare ventricular assist device.

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Correspondence: Korhan Erkanlı, MD, +90-212-6922000; fax: +90-212-4719494 (e-mail: kerkanli@gmail.com).

This continuous flow VAD provided an advantage while implanting due to no necessity of pump pocket. Despite this, a pocket was created by means of local resection of the diaphragm to be able to place the centrifugal blood pump, integrated inflow cannula, and outflow graft in an excellent position (Figure 1). In this way, inner parts of the device leaned against the peritoneum, avoiding abdominal pump placement. We did not use any spacers between the device and the apex of the heart. Flow management of the device was set at between 1.9-2.2 L/min and 2100-2300 rpm. The position of the pump within the chest and shadow of the heart is demonstrated in Figure 2. The patient was given a heparin infusion (30 units/kg/hour) according to prothrombin time test results until his warfarin (0.1 mg/kg/day) became therapeutic. The patient was discharged to home on postoperative 21 in good condition, with regular diet and full mobilization.

DISCUSSION

An approach to treating small patients who require heart transplantation may be challenging because children are limited by VAD size [Cabrera 2013]. For this reason, limited pericardial space and mediastinum may make implantation of the device uncomfortable. In addition to this, the size and part of short inflow cannula of VAD systems with continuous-flow, centrifugal pump may allow intrapericardial placement without device pockets [Miera 2011]. We had to create a pocket for parts of the intracorporeal system itself due to limited intrapericardial space, which was unique to this case. However, the literature is limited regarding intrapericardial, continuous-flow, centrifugal pump in patients younger than 18 years old or with BSA <1 m2 or body weight <20 kg. Moreover, to the best of our knowledge, the smallest supported child with a HeartWare VAD is 6 years old, and has a body weight of about 17 kg (BSA 0.7 m^2) [Miera 2011]. Therefore, our preference for this device as a bridge to transplantation in this case is notable because of the patient's young age (4 years old) and petite size (BSA 0.56 m^2).

There may be concerns regarding the difficulty in surgical technique for placement of a permanent adult device instead of another possibility, such as an extracorporeal circulatory support device, and it is a good idea in the long term as a bridge to transplantation in this small child. Surgical difficulty may be due to the significant angle of the VAD inflow relative to the heart. Correspondingly, the VAD may make the septum bend when there is a space constraint, especially in patients with a small chest. However, the observation that the patient's symptomatology has rapidly recovered after implantation of the left VAD supports our assessment that neither the flows are low for the device nor the inflow cannula obstruction or left ventricular septum compression. Furthermore, there was sufficient space for the left VAD pump housing, thanks to local resection of the diaphragm. Despite intrapericardial location of the device, this maneuver also minimized the possibility of the left VAD being compressed into the left ventricle septum or distorting the right ventricle and becoming obstructed during closure of the sternum. However, the position of the inflow system looks too close in contact to the ventricular septum on the chest X-ray. This point was documented by echo views. According to this, the position of the inflow system was away from the ventricular septum. Although the patient was doing well, decompression of the heart reflected moderately on the chest X-ray. This may be due to the dilated left ventricle also being hypertrophied. We feel that chest X-ray findings will be compatible with the clinical course of the patient with time.

Another issue, in contrast to bleeding complications of all devices, has been significant risk for thromboembolism at low flows. But the flows for the device were continuously adjusted according to clinical improvement in this patient. Besides, we thought that the final flows for the device implanted were within normal range according to patient's BSA. We strongly note that 2100-2300 rotations/min of the device ensured sufficient flow for this child. Moreover, the opening/closure of the aortic valve was documented to ensure a proper device flow.

In the current practice, it may be seen as a forceful implantation and a debate that such a large device would be indicated, and only a successful subsequent transplantation would help to answer this fundamental question. Unfortunately, although our intention after the device implantation was to do a transplant in this case, we still feel that our management decision will be merged into the destination therapy in the future due to our country's condition.

In conclusion, the intrapericardial, continuous-flow, centrifugal pump is feasible to consider in the younger pediatric population with end-stage heart failure. This report will also provide an updated clinical experience with regard to the usage of VAD in children very petite in size.

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