

# Neonatal ventricular assist device implantation for high-risk hypoplastic left heart syndrome: How we do it



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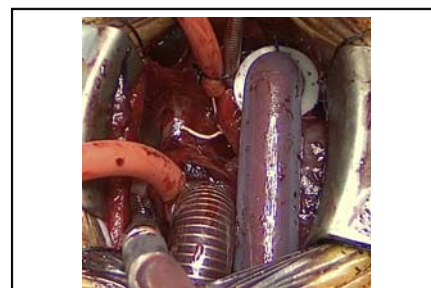
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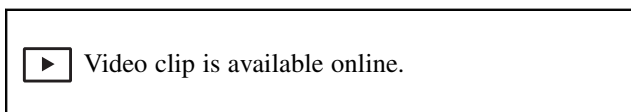
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Pulmonary artery and right atrial cannulation for VAD implantation in an HLHS neonate.

## CENTRAL MESSAGE

This report highlights the technical details and operative footage of continuous-flow ventricular assist device placement in an HLHS neonate less than 24 hours old.



Some neonates with single ventricle heart disease are poor candidates for surgical palliation, such as those with ventricular dysfunction, severe atrioventricular valve regurgitation, or unfavorable coronary anatomy. Recently, pulsatile-flow ventricular assist device (VAD) placement has emerged as a strategy to bridge these patients to transplantation.<sup>1</sup> However, few centers offer mechanical circulatory support for infants, and there is a paucity of technical reports and operative videos on the topic.<sup>2,3</sup> Furthermore, there is concern regarding insufficient atrial decompression and persistent venous congestion with pulsatile VAD in this population.<sup>4</sup> We present a video case report of a newborn with hypoplastic left heart syndrome (HLHS) and right ventricular (RV) dysfunction who received a continuous-flow VAD and hybrid stage I palliation as a successful bridge to transplantation.

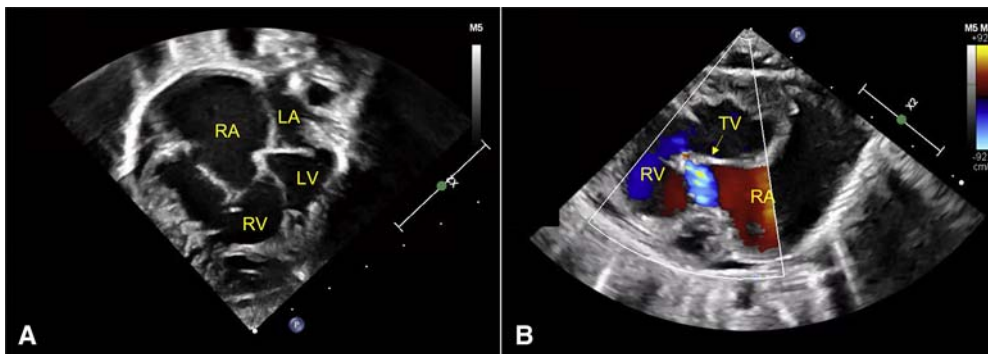
## CLINICAL SCENARIO

The patient was a term newborn male diagnosed prenatally with HLHS (mitral stenosis/aortic stenosis). Permission was granted by the patient's guardians to publish this report, and the institutional review board waived consent for this retrospective study (Pro00101549, May 2020). Transthoracic echocardiogram at birth demonstrated findings consistent with HLHS and an RV with severely

depressed function and coarse trabeculations consistent with noncompaction cardiomyopathy (Figure 1, A). The tricuspid valve was apically displaced, with a tethered septal leaflet (Ebstein-like) and moderate-to-severe regurgitation (Figure 1, B). On day of life (DOL) 0, the patient was intubated for worsening lactic acidosis and pulmonary edema suggestive of cardiogenic shock. Given his clinical decompensation with severe ventricular dysfunction and tricuspid regurgitation, performing isolated pulmonary artery (PA) banding or a hybrid Norwood operation would have been insufficient to bridge the patient to transplant in our experience. Therefore, we proceeded with continuous-flow VAD implantation and hybrid stage I palliation with bilateral (PA) banding and atrial septectomy on DOL1.

## SURGICAL TECHNIQUE

The surgical technique is detailed in Video 1. After median sternotomy and pericardiotomy, the great vessels were dissected circumferentially. Pursestring sutures were placed in the distal ascending aorta and right atrium. A 24-F right angle venous cannula was tunneled under the right costal margin using curved Kelly forceps and a latex



**FIGURE 1.** Transthoracic echocardiogram at birth. A, Apical 4-chamber view demonstrating severely hypoplastic LV, coarsely trabeculated RV, and apical displacement of the tricuspid valve. B, Parasternal long axis view demonstrating moderate-to-severe tricuspid valve regurgitation. RA, Right atrium; LA, left atrium; LV, left ventricular; RV, right ventricular; TV, tricuspid valve.

cap to minimize trauma (Figure 2, A). This larger cannula was chosen to accommodate the high total flows, up to 7 to 9 L/min/m<sup>2</sup>, expected after neonatal PA banding (pulmonary flow + systemic flow with estimated pulmonary flow:systemic flow ratio of 1.5:1-2:1 and body surface area 0.23 m<sup>2</sup>). A 5/6 Berlin Heart arterial cannula was tunneled under the left costal margin. After heparinization, the ascending aorta was cannulated with an 8-F arterial cannula and the right atrial appendage was cannulated. The patient was cooled to 32 °C on bypass. In the case of a small ascending aorta measuring less than 4 mm, direct innominate artery cannulation is performed instead.<sup>5</sup>

Under brief circulatory arrest, a Yasargil clip was placed distal to the aortic cannula and the heart was arrested with del Nido cardioplegia via the aortic cannula side port. After myocardial arrest, the clip was moved proximal to the cannula as a crossclamp. Bypass flow was resumed.

Next, an atrial septectomy was performed under pump sucker bypass. Bypass flow was reduced and an atriotomy was performed. Drop-style pump suckers were introduced into the vena cavae through the atrial incision and the septum was fully resected. The atrium was closed in 2

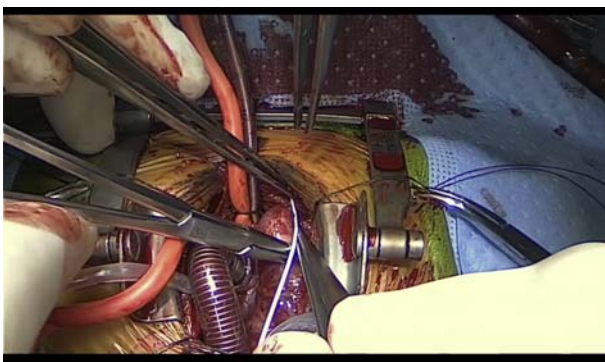
layers with running 6-0 polypropylene and regular bypass flow was resumed.

Attention was turned to VAD outflow cannulation. A 4-mm circular punch was used to create an arteriotomy in the main PA. Two doubled-armed 5-0 polypropylene sutures were placed circumferentially around the arteriotomy as previously illustrated<sup>6</sup> and brought up through the sewing ring of the Berlin cannula at the 6- and 12-o'clock positions. The cannula was secured into the PA.

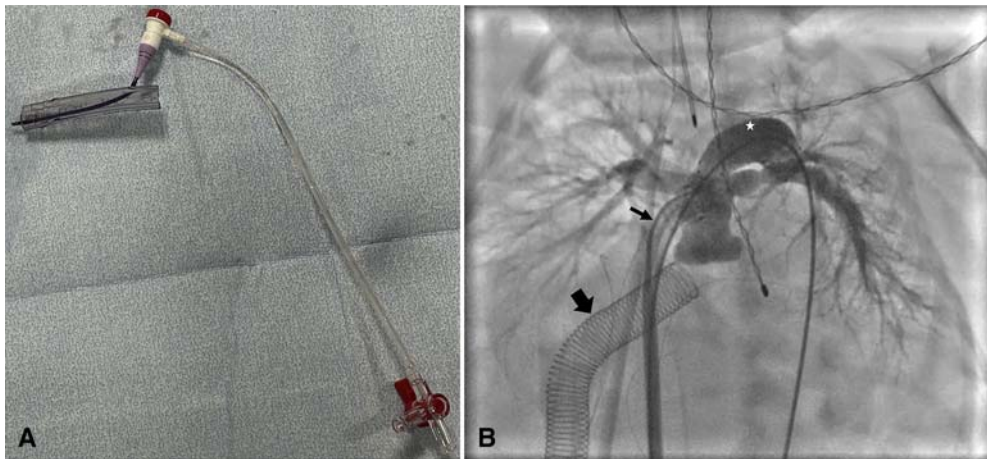
The aortic crossclamp was removed and rewarming initiated. The PA bands were placed by tying a CV-0 Gore-Tex tie over a 3-mm dilator on each branch PA. The patient was weaned from bypass. The VAD cannulas were connected to an Abbott PediMag blood pump after deairing and a supra-therapeutic cardiac index of 7.0 to 9.0 L/min/m<sup>2</sup> was gradually achieved on VAD support. The aortic cannula was removed, protamine administered, and a 19-F Blake drain was left in the mediastinum. A silastic membrane was placed on the open chest.

**POSTOPERATIVE COURSE**

The chest was closed on POD1 and bivalirudin was started. Two ductal stents (EV3 Protege self-expanding, 8 mm × 2 cm) were placed on POD2 by accessing the VAD arterial cannula with a 7-Fr sheath using the Seldinger technique after sterile preparation (Figure 2). The patient was weaned off inotropes on POD4 and remained hemodynamically stable on VAD flows of 7.0 to 9.0 L/min/m<sup>2</sup>, or 1.5 to 2.0 L/min (2400 rpm). Transthoracic echocardiogram on POD4 demonstrated well-seated VAD cannulas and ductal stent, opening of the native aortic valve with every beat, severely diminished RV function, severe tricuspid regurgitation, and continuous antegrade flow across both branch PAs. Extubation was performed on POD19. There were no thromboembolic complications on VAD support, and the patient received a heart transplant 4 months later on POD127.



**VIDEO 1.** Preoperative imaging, operative footage, and discussion of VAD implantation in a neonate. Video available at: [https://www.jtcvs.org/article/S2666-2507\(22\)00360-1/fulltext](https://www.jtcvs.org/article/S2666-2507(22)00360-1/fulltext).



**FIGURE 2.** Ductal stent placement. A, Access through 7-Fr sheath placed in VAD tubing leading to the pulmonary artery cannula. B, Completion angiogram showing ductal stent (*white star*), VAD arterial cannula with wire access (*small arrow*), and venous cannula (*large arrow*).

### COMMENT

In this case report, we demonstrate continuous-flow VAD placement and hybrid stage I palliation as a bridge to transplantation in a neonate with HLHS. We believe there are 3 notable aspects to this report. First, to our knowledge, operative footage of a neonatal VAD implantation has not been published, and our video may serve as a useful reference. Second, our patient underwent VAD implantation at less than 24 hours of age, which is younger than patients reported in previous series. Lastly, rather than using a Dacron graft extension, we directly place the Berlin cannula into the main PA, which may eliminate a potential bleeding source.

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