HEARTMATE BIVAD: HOW SMALL CAN WE GO AND IS IT WORTH THE CHALLENGE?

Matthew J. O'Connor, MD

Medical Director, Heart Transplant Program Staff Cardiologist, Heart Failure/Transplant/MCS Children's Hospital of Philadelphia

CHOP Cardiology 2024 February 16, 2024





DISCLOSURES

- No financial disclosures or other conflicts of interest
- I am not a surgeon



OBJECTIVES

- Indications for BiVAD
- Outcomes of BiVAD in children
- Size considerations for HM3 BiVAD
- All in the context of case studies





CASE STUDY #1

- 10 y/o female with D-TGA/IVS
 - Underwent arterial switch operation with LeCompte during infancy with unremarkable postoperative course
 - Circumflex from RCA
 - Underwent balloon dilation of supravalvular PS at 3 y/o
- Fall 2022 (9 y/o)
 - Syncope at school (3rd episode in 3 months)
 - Troponin-I elevated (8.9)
 - ECG changes
- 38 kg, BSA 1.4 m²













ABBREVIATED HOSPITAL COURSE





HM3 RVAD – SURGICAL TECHNIQUE

- Right atrial cannulation via 20 mm GoreTex graft to VAD inflow
- Outflow graft to MPA
- Pocket created between rectus abdominus muscle and diaphragm to avoid right lung compression from VAD



A novel intracorporeal right ventricular assist device implantation technique in a young patient



Constantine D. Mavroudis, MD, MSc, MTR, Madison A. Grasty, MD, MS, Kathryn Restaino, MD, Catherine M. Montgomery, BSN, RN, CPN, Alee N. Pettit, BS, Matthew J. O'Connor, MD, Carol Wittlieb-Weber, MD, Jonathan B. Edelson, MD, Jonathan Edwards, MD, Justin Berger, MD, PhD, Kimberly Lin, MD, Joseph Rossano, MD, and Katsuhide Maeda, MD, PhD, Philadelphia, Pa

JTCVS Tech 2024;23:89-91

We demonstrate a novel method of intracorporeal RVAD placement that can be used in children or small adults to allow for discharge while awaiting cardiac transplantation. By positioning the VAD pump away from the heart and right lung, this technique avoids tricuspid valve leaflet interference or pulmonary compression that can complicate RVAD placement in smaller patients. This technique leverages surgical methods similar to those used with the HeartMate II and graft extension techniques that are used in patients with small ventricular cavities.¹ Although the concept of using an interposition graft to distance the pumphead from the heart has been described,¹ to our knowledge, this is the first time that graft extension and chest wall fixation has been performed in an RVAD. Positioning the pump away from the heart has advantages, including eliminating the need to alter pump inflow by having the pump sit more shallowly²; avoiding inflow malposition and the potential for tricuspid valve dysfunction or valvectomy³; and minimizing risk of dynamic right ventricular outflow track obstruction. Avoiding tricuspid valvectomy is important, as right ventricular contraction can cause large V waves that can increase venous congestion and end-organ damage. By positioning the pump away from the hilum, there may be less atelectasis, less interference with right lung mechanics, and there may be less risk of right phrenic nerve injury at the time of transplantation that has been





CASE STUDY #2

- 11 y/o boy with mesocardia, L-TGA, pulmonary atresia
- Most recently status post Senning/Rastelli with 18 mm RV-PA conduit (LV as systemic ventricle)
- Complete heart block, pacemaker dependent
- Chronic heart failure, on milrinone infusion, listed for transplant
- Highly sensitized
- 27.4 kg, BSA 1.0 m²









Option 1



Option 2



Option 3

BIVAD INDICATIONS

- Biventricular heart failure not adequately treated with LVAD-only support
 - AKA right heart failure after LVAD implantation
- Transplant graft dysfunction
- Severe myocarditis
- Restrictive cardiomyopathy
- Arrhythmia-induced cardiomyopathy
- Congenital heart disease (uncommon)



BIVAD IN PEDIATRICS



13% of entire cohort

Children's Hospital of Philadelphia

Adachi et al Ann Thorac Surg 2023

BIVAD IN PEDIATRICS

TABLE 1 Characteristics of Pedimacs Patients (N = 1109), September 19, 2012-December 31, 2021

Characteristics	Overall (N = 1109)	Paracorporeal Pulsatile (n = 306)	Paracorporeal Continuous (n = 293)	Implantable Continuous (n = 448)	P Value*
Device type					
LVAD	913 (82.3)	235 (76.8)	220 (75.1)	404 (90.2)	<.0001
RVAD	48 (4.3)	7 (2.3)	28 (9.6)	12 (2.7)	<.0001
BIVAD	144 (13.0)	64 (20.9)	45 (15.4)	32 (7.1)	<.0001
TAH	4 (0.4)	444		***	

Adachi et al Ann Thorac Surg 2023



BIVAD IN PEDIATRICS

Utilization and outcomes in biventricular assist device support in pediatrics

Nathanya Baez Hernandez, MD,^a Richard Kirk, MA, FRCP,^a David Sutcliffe, MD,^a Ryan Davies, MD,^b Robert Jaquiss, MD,^b Ang Gao, MS,^c Song Zhang, PhD,^c and Ryan J. Butts, MD^a

Survival After Propensity Score Matching 1009 80% 60% Overall 40% P-value = .31, log-rank 20% 0% 2 0 Months After Implant - BiVAD 40 14 - LVAD 80 41 27 15

N = 63 49% with cfVAD in BiVAD configuration

JTCVS 2020

Check for updates

FIGURE 2. Survival in the matched cohort. Kaplan–Meier curve depicting survival after VAD implant for propensity score–matched patients, with patients on LVAD depicted by a *blue curve* and those on BiVAD by a *red curve*. No difference was seen in survival between cohorts. Patients censored at time of transplant and/or at device explant for recovery. *Shaded areas* indicate 95% confidence intervals for each group. *BiVAD*, Biventricular assist device; *LVAD*, left ventricular assist device:









HOW SMALL CAN YOU GO?

- Smallest HM3 (LVAD) patient in ACTION¹
 - 17.7 kg (BSA 0.73 m²)
 - BiVAD excluded in this study
- Smallest HM3 BiVAD in ACTION uncertain
- TCH experience²
 - 100 patients with intracorporeal VADs 2008 2022
 - 67 HVAD
 - 17 HM2
 - 16 HM3

¹O'Connor et al J Heart Lung Transplant 2023 ²Cho et al J Thorac Cardiovasc Surg 2023



	<u>Total</u> n = 100	HeartMate II	HeartWare HVAD n = 67 2011-2021	HeartMate 3	
		n = 17		n = 16	
		2008-2014		2020-2022	
Demographics					
Male	67 (67%)	14 (82%)	41 (61%)	12 (75%)	
Age, y	14.1 (3.0-56.5)	15.1 (10.1-18.3)	11.9 (3.0-26.0)	16.3 (8.6-56.5)	
Body weight, kg	54.8 (13.3-140)	61 (47.5-140)	42.2 (13.3-121)	66.5 (29.8-126)	
Body surface area, m ²	1.6 (0.6-2.6)	1.7 (1.5-2.6)	1.3 (0.6-2.5)	1.8 (1.1-2.5)	
Etiology of heart failure					
Cardiomyopathy	58 (58%)	11 (65%)	40 (60%)	7 (44%)	
CHD	37 (37%)	3 (18%)	25 (37%)	9 (56%)	
Single ventricle	13 of 37	1 of 3	11 of 67	1 of 16	
Cardiac graft dysfunction	2 (2%)	1 (6%)	1 (1%)	-	
Myocarditis	2 (2%)	1 (6%)	1 (1%)	-	
Septic shock	1 (1%)	1 (6%)	-	-	
Support type					
LVAD or SVAD	98 (98%)	17 (100%)	65 (97%)	16 (100%)	
BiVAD	2 (2%)	-	2 (3%)	-	
Support duration, mo	8.05 (8 d-138.2)	3(17 d - 12.4)	9.1 (8 d-138.2)	11.6(1.9-35)	

TABLE 1. Patient characteristics by device type





Diagram providing pump weights and cannula lengths for the HeartMate 3[™] and HVAD[™]



Α

В

[™] LVAD
Inflow
Length = 22mm



HVAD [™] System				
Pump	Inflow			
Mass (or weight) = 160 g	Length = 32.3mn			
Volume = 50 mL				

SO, HOW SMALL CAN YOU GO?

- There is no "magic" patient size/weight
- However, lowest weight and BSA is probably ~30 kg/1.2 m² BSA
- Patients smaller than this needing biVAD likely best served by the EXCOR



IS IT WORTH IT?

- No one looks forward to placing a biVAD
- But they can be used with success
- Potential for discharge home is a huge plus
- When both ventricles are failing, there really is no alternative



