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

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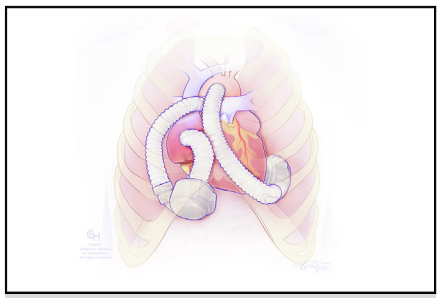

Novel intracorporeal RVAD cannulation technique in a small patient.

CENTRAL MESSAGE

Intracorporeal RVAD placement in a young patient can be facilitated through the use of atrial cannulation, pre-pump interposition graft, and pumphead positioning along the diaphragm.

Controversy exists regarding optimal device selection and long-term strategy for biventricular support in children and small adults. Use of intracorporeal devices such as the HeartMate 3 (HM3; Abbott Laboratories) for both left ventricular assist device (LVAD) and right ventricular assist device (RVAD) can facilitate home discharge, but HM3 RVAD implant is limited by cannulation location, flow rates, and intrathoracic cavity space. Right atrial cannulation technique on its lateral wall has been performed but can be complicated by inflow obstruction from tricuspid valve leaflets and chronic right lung compression with resultant atelectasis or pulmonary vein compression. To obviate these challenges, we employed a novel implant technique that positions the HM3 RVAD pump away from these structures while maintaining optimal inflow.

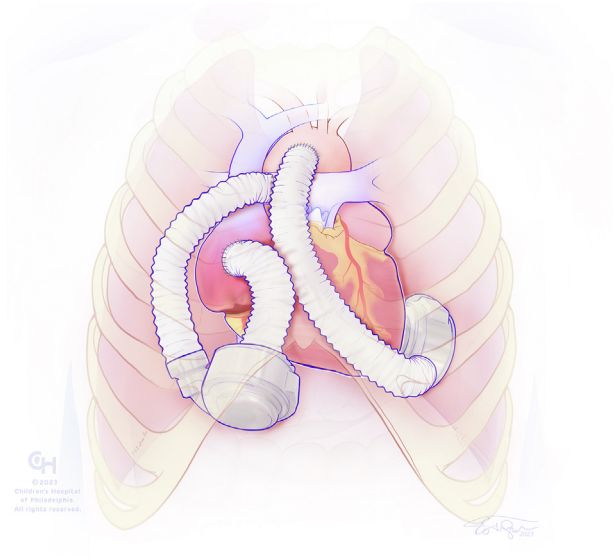

FIGURE 1. Illustration depicting HeartMate 3 RVAD cannulation technique in a small patient. Note the interposition graft between RVAD pump inflow and the right atrium, the inferior position of the RVAD pump, the transposed great vessels, and pulmonary valve replacement.

CASE REPORT

Per institutional protocol, retrospective studies of fewer than 5 patients are exempt from institutional review aboard review. Therefore, this study was exempt from institutional review aboard approval and individual consent. We present a case of intracorporeal biventricular assist device (HM3) in a 9-year-old, 38-kg (body surface area 1.4 m^2) patient. The patient has a history of dextro-

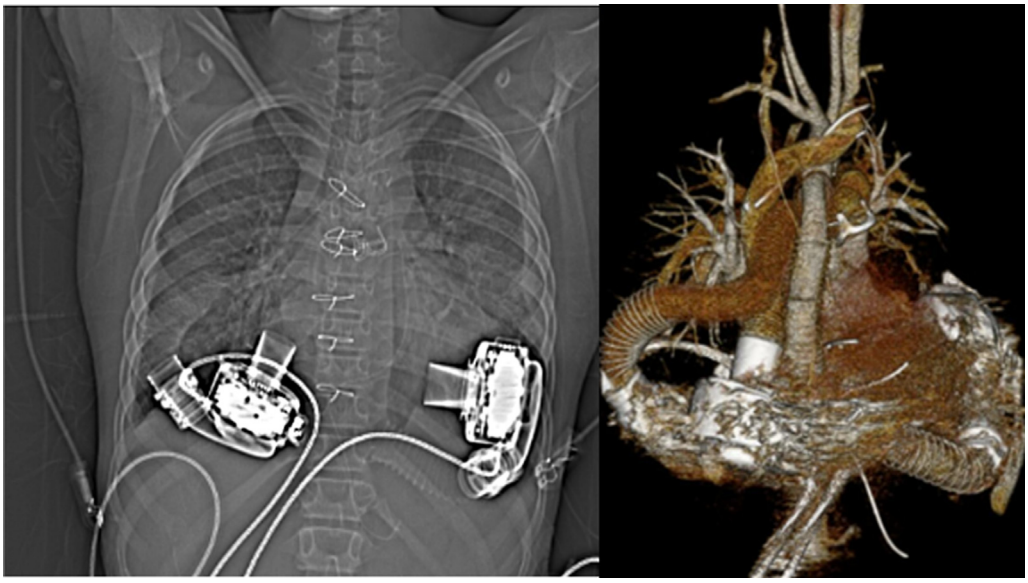

FIGURE 2. *Left panel*: anteroposterior chest radiograph demonstrating the positions of the RVAD and LVAD. *Right panel*: 3-dimensional reconstruction of a computed tomography scan demonstrating placement of ventricular assist devices. Note the inferior position of the RVAD pumphead and the interposition graft between the pumphead and right atrium.

transposition of the great vessels, status postneonatal arterial switch, who presented with syncopal episodes with exercise, ST-segment changes, and elevated troponin levels. Cardiac catheterization demonstrated patent coronary arteries. She progressed to shock and underwent urgent venoarterial extracorporeal membrane oxygenation (ECMO) cannulation for presumed myocarditis. When ventricular function did not improve after 13 days of ECMO support with septostomy for ventricular unloading, she underwent HM3 LVAD, atrial septal defect closure and temporary RVAD (CentriMag; Abbott Laboratories). She could not be weaned from her temporary RVAD after 20 days of mechanical support and was taken for durable RVAD placement (HM3) and pulmonary valve replacement (19-mm INSPIRIS bioprosthesis; Edwards Lifesciences) for severe pulmonary insufficiency. This procedure was performed on cardiopulmonary bypass without aortic crossclamping. In order to accommodate a pump without right lung compression, a pocket was created for the HM3 pump between the posterior sheath of rectus abdominus muscle and the right diaphragm under the rib cage. A ringed 20-mm polytetrafluoroethylene graft (W.L. Gore & Associates) was sewn to the right atrial wall and was connected to the HM3 inflow (Figures 1 and 2). The outflow was then sewn to the pulmonary artery. RVAD rpms were set approximately 75% that of LVAD (4300 and 5600) to maintain right atrial pressure between 7 and 8 mm Hg and left atrial pressure of approximately 10 mm Hg. On surveillance catheterization, no further changes were made to VAD settings, and there were no gradients noted to suggest any cardiac chamber compression or obstruction. She was extubated on postoperative day 6. She was able to be discharged home 62 days following RVAD placement and continues to do well awaiting cardiac transplantation.

DISCUSSION

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 shallowly[2]; avoiding inflow malposition and the potential for tricuspid valve dysfunction or valvectomy[3]; 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

described.[4] Technical points to consider include properly securing the polytetrafluoroethylene graft to pump inflow (zip ties), and securing the pump head to the rib to prevent malpositioning. The patient has been maintained on standard VAD anticoagulation without thrombotic complications. Optimal strategies for right ventricular support in children and small adults remain incompletely understood. This strategy overcomes several issues encountered in RVAD placement in smaller patients and may prove beneficial in select patients to facilitate home discharge and rehabilitation.

Conflict of Interest Statement

J.R. reported consultant for Bayer, Merck, Bristol Myers Squibb, and AskBio. K.M. reported surgical consultant for Berlin Heart, Abbott Laboratories, and PECA Labs. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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References

1. Maeda K, Nasirov T, Yarlagadda V, Hollander SA, Navarathnum M, Rosenthal DN, et al. Novel trans-septal left atrial VAD cannulation technique for hypertrophic/restrictive cardiomyopathy. *J Heart Lung Transplant*. 2019;38:S479.
2. Potapov EV, Kukucka M, Falk V, Krabatsch T. Biventricular support using 2 HeartMate 3 pumps. *J Heart Lung Transplant*. 2016;35:1268-70.
3. Nandi D, Miller KD, Bober CM, Rosenthal TM, Montenegro LM, Rossano JW, et al. Systemic atrioventricular valve excision and ventricular assist devices in pediatric patients. *Ann Thorac Surg*. 2018;105:170-4.
4. Schulz A, Potapov E, Cho MY. Intracorporeal biventricular assist device therapy in an 8-year-old. *Semin Thoracic Surg*. 2018;31:110-1.