Dynamic superior vena cava occlusion with an atrial implanted pediatric right ventricular assist device

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A HeartMate 3 right ventricular assist device (RVAD) was implanted 5 months after a left ventricular assist device (LVAD) in a pediatric patient, due to late onset of right heart failure and deterioration of right ventricular function that did not respond to maximal medical therapy. Herein, we describe the early manifestation of a dynamic superior vena cava occlusion syndrome due to RVAD suction effect that was successfully managed.

CLINICAL SUMMARY

A previously healthy 14-year-old boy presented to our emergency department following a 14-day history of flu-like illness with fever and malaise. Vital signs were abnormal, including tachycardia, tachypnea, and hypotension. Electrocardiogram showed sinus tachycardia, first-degree atrioventricular block, and complete left bundle branch block. Transthoracic echocardiography showed marked left ventricular dilation, severely decreased ventricular function, and moderately depressed right ventricular function. A radiograph of the chest showed an enlarged cardiac silhouette (Figure 1). Cardiac magnetic resonance imaging and myocardial biopsy confirmed the diagnosis of acute myocarditis associated with the H1N1 influenza virus. Despite maximal medical therapy, refractory cardiogenic shock ensued, requiring circulatory support with the Impella 2.5 I (Abiomed, Inc, Danvers, Mass) percutaneous microaxial pump. Twenty-four hours postimplant, right ventricular function deteriorated, mandating a temporary support with the Protek Duo (LivaNova PLC, London, UK) dual-lumen cannula inserted percutaneously via the right internal jugular vein and connected to a centrifugal pump. After 8 days, a HeartMate 3 (Abbott, Chicago, Ill) LVAD was implanted as a bridge to recovery.1,2 Forty-two days later, the right ventricle showed sufficient recovery, and the temporary mechanical support was weaned off and a dual-chamber permanent pacemaker was implanted for complete heart block. However, 5 months later, the right ventricle failed again, tricuspid regurgitation became severe (mean right atrial pressure of 20 mm Hg), and a durable RVAD was needed. The HeartMate 3 was selected as the device of choice based on the encouraging report of Lavee and colleagues3 (to reduce the protrusion of the inflow cannula into the right atrium, the thickness of the cuff was increased using 5 layers of polytetrafluoroethylene felt fixed together with the BioGlue [CryoLife, Guildford, UK] and cored as usual). Then, the thickened sewing ring cuff was sutured...
to the atrial wall with pledgeted sutures. The right pleura was widely opened to accommodate the pump within the right chest cavity as described by Folino and colleagues. The outflow graft, sewn to the main pulmonary artery, was not purposely narrowed.

The odds of myocardial recovery were then thought to be small, and the patient was listed for heart transplant. In the immediate postoperative period following the atrial implantation of the RVAD, a significant rise in the central venous pressure up to 18 mm Hg was noticed. The findings from transesophageal echocardiography suggested superior vena cava stenosis (Figure 2, Video 1); therefore, the patient was taken to the catheterization laboratory to confirm the diagnosis. Angiography showed absence of compression of the HeartMate 3 device on the superior vena cava but a discrete narrowing at the level of the superior vena cava–right atrial junction with an invasive pressure gradient of ~7- to 8 mm Hg. A balloon dilatation catheter was introduced and inflated in the vessel, showing an extremely compliant lesion with no waist (Videos 2 and 3); a dynamic superior vena cava obstruction caused by the RVAD suction effect was then hypothesized. The rpms of the RVAD were decreased (keeping the right output 700 mL lower than the left output), and a repeated angiography showed almost complete resolution of the lesion and reduction in the superior vena cava to right atrium pressure gradient (Video 4). Serial radiographs of chest showing the position of the devices at different time points are shown in Figures 3-6.

Informed consent for the publication of the study data was obtained from the parents of the child.

**DISCUSSION**

Continuous-flow RVAD support is challenging due to the limited ability of the pump to respond to left/right flow imbalances caused by “mismatching” of left and right pump support. The atrium low resistance is prone to inlet cannula suck-down during transient periods of low circulating blood volume or during low left-side output. Based on our
experience, we suggest to keep RV AD flow around 75% of the LVAD flow to avoid this complication. Of course, the balance between the left and right circulations is variable and needs to be determined on individual basis.

In this case, we decided to implant the RVAD into the right atrium, given the fact that the right ventricle is associated with many trabeculations, which may lead to a greater rate of suction events. We sutured several layers of felt pledgets onto the sewing ring of the HeartMate 3 to reduce the penetration depth of the inflow cannula.
into the right atrium, and downsizing of the RVAD outflow graft diameter was not used. The patient is currently awaiting heart transplant.

References
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