ASK THE EXPERT

Is There a Role for Percutaneous or Surgically Implanted Right Ventricular Assist Devices in Pulmonary Arterial Hypertension?

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The development of right ventricular (RV) failure in patients with pulmonary arterial hypertension (PAH) is associated with a dismal prognosis. While phosphodiesterase-5 inhibitors, prostacyclin analogs, endothelin receptor antagonists, and other medications have transformed the prognosis of PAH, these therapies have limited effectiveness. A subset of patients develops right heart failure in the face of severely elevated pulmonary vascular resistance (PVR) despite optimal medical management. The appropriate role for mechanical support of the failing RV in the context of PAH remains undefined.

There is rapidly growing experience with left ventricular assist devices (LVADs) to provide mechanical circulatory support, both percutaneous and durable surgical options. RV assist devices (RVADs) have also been increasingly used; for example, to provide temporary RV support in patients with acute myocardial infarction involving the RV. PAH, however, is associated with additional obstacles to RV mechanical support. For one, increasing pulmonary flow can cause harm in the setting of fixed, elevated PVR. Risks include pulmonary hemorrhage and pulmonary edema, due to either increasing pulmonary arterial (PA) pressures or indirect adverse effects on left ventricular (LV) filling.[1]

Currently, LV support can be considered in diverse circumstances. A key question is how long mechanical support is likely to be needed; some devices provide temporary support, while others can provide durable support for years. When extrapolated to RV support in PAH, acute RV decompensation can occur at the time of initial PAH presentation, before starting PAH-specific therapies, or in patients with longstanding PAH because of acute illness. In these contexts, temporary RV support could be used until recovery or until optimization of pulmonary vasodilator therapy. Durable RV support can be considered in situations with patients with end-stage PAH and progressive symptomatic RV failure despite optimal medical therapy awaiting organ transplantation. Punnoose et al have explored computational models of RVAD effects on pulmonary vascular, peripheral vascular, RV, and LV hemodynamics at various stages of PAH and RV failure.[1] These models predict that RVAD support would improve RV hemodynamics (eg, higher pulmonary flow, lower right atrial pressure), but at the cost of increased pulmonary pressures. Maintaining low RVAD flow rates may mitigate the associated risk, but this approach would limit benefit and is restricted by rotational limits and related risk of thrombosis.

Key Words—pulmonary arterial hypertension, right ventricular assist device, mechanical circulatory support, right heart failure
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Disclosure: The authors have no relevant personal financial relationships to disclose.

Several options exist for temporary RV support, including the Impella-RP (Abiomed, Danvers, Massachusetts), TandemHeart (LivaNova, London, UK), and CentriMag (Abbott, Chicago, Illinois). Off-label use of durable LVADs surgically implanted in the RV position, such as the HeartWare Ventricular Assist Device (HVAD; HeartWare, Framingham, Massachusetts) and HeartMate III (Abbott), has also been reported. The Impella-RP is an 11 French axial-flow pump placed through a femoral vein with blood inflow provided from the inferior vena cava and outflow directed into the main PA at up to 4.0 L/min. The TandemHeart is an external continuous flow pump that can provide up to 5 L/min of flow with speeds up to 7500 rpm. The use of the TandemHeart with a ProtekDuo catheter (LivaNova) allows for single-site vascular access via the right internal jugular vein; inflow to the pump is from the RA, and outflow is directed to the main PA. Above-the-diaphragm access facilitates patient mobility and rehabilitation. The CentriMag device is an extracorporeal continuous flow pump compatible with various cannulation strategies, placed either surgically or percutaneously, that can provide up to 9.9 L/min of flow. Durable surgical cannulation also enables easier ambulation and rehabilitation and is currently approved for humanitarian use up to 30 days for cardiogenic shock. Both continuous flow pump options, TandemHeart and CentriMag, can incorporate an oxygenator into the circuit to provide oxygenation in addition to hemodynamic support. Finally, the HVAD and the HeartMate III are surgically implanted LVADs which have been used off-label as durable RVADs; currently, there are no FDA-approved durable RVADs.[2,3]

Despite these many options, the published experience using RVADs in patients with PAH remains limited to case reports.[4–6] Rosenzweig et al describe a patient with longstanding PAH with progressive RV failure and recurrent hospitalizations despite maximal medical therapy.[4] Given safety concerns, a staged approach was used. First, a trial of temporary percutaneous RV support was provided with cannulation of the internal jugular vein using a ProtekDuo cannula connected to a CentriMag pump. Low flows (1.0 L/min) were initiated, increasing mean PA pressure ~8 to 10 mm Hg, without complications. Flows were gradually increased to 2.0 L/min with no further increase in PA pressure. Based on this favorable response, a durable HVAD was then implanted. Vullaganti et al also report a patient with RV failure in the setting of chronic thromboembolic pulmonary hypertension.[5] Temporary RVAD support was provided with a ProtekDuo cannula connected to a TandemHeart pump. There were no acute complications, and there was short-term improvement with flows up to 3.7 L/min; durable RVAD support was then pursued with an HVAD. Both patients ultimately died due to septic shock within 1 to 4 weeks after HVAD implantation.

Experience is far too limited to provide confidence in the safety or effectiveness of isolated RV mechanical support with PAH, even for the few patients without alternative options who might be considered. At the same time, the growing experience with and improving outcomes of other approaches, such as extracorporeal membrane oxygenation and pumpless membrane ventilators (eg, Novalung device, Xenios, Heilbronn, Germany), have further narrowed the potential role for RVAD support in PAH.[7,8]

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