Right Ventricular Outflow Tract Cannulation for Right Ventricular Assist Device Implantation

Howard K. Song, MD, PhD, Frederick A. Tibayan, MD, James Mudd, MD, Jill Gelow, MD, and Matthew S. Slater, MD

Divisions of Cardiothoracic Surgery and Cardiovascular Medicine, Oregon Health and Science University, Portland, Oregon

A need persists for implantable devices that provide support for the failing right ventricle. The anatomy of the right ventricle presents unique challenges at the time of right ventricular assist device implant. We describe a technique for right ventricular outflow tract cannulation that minimizes the risk of right ventricular assist device inflow cannula obstruction and right ventricular compression. (Ann Thorac Surg 2013;96:333–5) © 2013 by The Society of Thoracic Surgeons

Advances in left ventricular assist device (LVAD) technology have led to increased use of mechanical circulatory support. A need persists for implantable devices that provide support for the failing right ventricle. Up to 20% of patients undergoing LVAD implantation also have right ventricular failure [1]. Current devices approved for right ventricular or biventricular support (PVAD and IVAD; Thoratec, Pleasanton, CA) have large cannulae that traverse the body wall and are inappropriate for long-term outpatient therapy [2]. To address this need, a number of centers have reported the use of an LVAD (HeartWare International, Miami Lakes, FL) in a right ventricular assist device (RVAD) configuration to support patients with right and biventricular failure [3–5].

The morphology of a failing right ventricle is distinct from that of a left ventricle and as a consequence, implantation of an RVAD presents unique challenges. The failing right ventricle is less spherical than the left ventricle. The right ventricular cavity deep to the free wall is traversed by the subvalvar apparatus of the tricuspid valve and the moderator band. These structures increase the likelihood of RVAD inflow cannula obstruction and have led to the development of alternative implant techniques to lessen this possibility [6, 7]. Here, we describe a technique of right ventricular outflow tract cannulation for RVAD implant that provides a free space within the chamber for the inflow cannula and allows the RVAD pump housing to sit in an extrapericardial location, decreasing the risk for right ventricular compression and tamponade.

Technique

A 54-year-old man had a diagnosis of nonischemic cardiomyopathy and progressive biventricular heart failure complicated by congestive hepatopathy and renal failure. He failed medical management with oral agents, intravenous inotropes, and intraaortic balloon pump counterpulsation. He was supported with a percutaneous LVAD (Tandem Heart; CardiacAssist, Pittsburgh, PA) and continuous venovenous hemofiltration. His right ventricle failed to improve despite unloading of the left ventricle and removal of fluid, and it became apparent that he would require long-term biventricular support. After appropriate regulatory approval, the patient was offered an emergency-use implant of two HeartWare VADs for long-term biventricular support.

The patient was taken to the operating room. A sternotomy was performed, and the pericardium was opened widely beyond the apex to avoid pericardial compression of the heart. A cardiopulmonary bypass was performed, and the percutaneous LVAD was removed. The foramen ovale was not closed. A HeartWare LVAD was implanted in the standard fashion.

Several right ventricular cannulation options were evaluated. There was concern for inflow cannula obstruction and right ventricular compression if the VAD was implanted into the right ventricular free wall, particularly after sternal closure potentially compressing the RVAD into the right ventricle and the inflow cannula into the interventricular septum. The RVAD sewing ring was therefore secured to the left aspect of the right ventricular outflow tract. Four rings of felt pledget material were placed as a spacer between the sewing ring and the surface of the outflow tract to limit the depth of the inflow cannula within the right ventricle. A ventriculotomy was made using a coring knife and the VAD inflow cannula was placed into the right ventricle. The RVAD inflow cannula was directed toward the proximal right ventricular outflow tract and tricuspid valve.

The pericardium was slit and placed around the RVAD inflow cannula (Fig 1). This slit was in a similar location to where the pericardium is commonly incised to allow a left internal mammary artery pedicle to pass into the pericardial sac during coronary artery bypass surgery.
The RVAD pump housing therefore was extrapericardial in the left chest, just superior to the hilum of the left lung. This extrapericardial location minimized the possibility of the RVAD being compressed into the right ventricle and becoming obstructed at the time of chest closure (Fig 2). The RVAD outflow graft was cut and anastomosed to the proximal pulmonary artery.

Biventricular VAD support was initiated, and the patient was weaned from cardiopulmonary bypass without inotropic support. The RVAD outflow graft diameter was constricted approximately 30% using surgical clips to increase afterload on the RVAD and allow it to be set at an appropriately high speed without causing suction events. The patient’s chest was closed and the patient was taken to the intensive care unit. The remainder of the patient’s hospitalization was unremarkable. He was given a heparin infusion until his warfarin became therapeutic. He had good circulatory support from his VADs and his end organ function recovered. He did not require dialysis postoperatively. He did have severe deconditioning from his prolonged critical illness, but had substantial recovery of this and was able to be discharged to home 4 weeks after surgery. At the time of his discharge, his RVAD speed was 2400 rpm, his RVAD flow was 6.1 L/min, and pump power was 3.1 W. The LVAD speed was 2420 with flow of 4.8 L/min and power of 2.9 W. He has now been supported for longer than 3 months with similar VAD flows and settings and class I symptoms. He has not developed significant pulmonary insufficiency.

Comment

Current ventricular assist devices have been developed and designed for left ventricular support. The crescentic shape of the right ventricle is distinct from the left ventricle, resulting in unique surgical challenges at the time of RVAD implantation. Several methods of HeartWare RVAD cannulation have been described, including cannulation of the RV free wall, the diaphragmatic surface, and the right atrium [5–7]. The latter two methods were developed specifically to address the problem of inflow cannula obstruction seen with free wall cannulation. Here, we describe a novel technique of right ventricular outflow tract cannulation with extrapericardial placement of the RVAD pump housing in the left pleural cavity.

There are a number of potential advantages to this method. The inflow cannula is directed parallel rather than toward the interventricular septum. The tip of the cannula is pointed toward the tricuspid valve, but is removed from its subvalvular apparatus and the moderator band. This technique decreases the likelihood of inflow cannula obstruction from these structures. The blood path through the right ventricle and into the proximal RVOT is preserved, potentially decreasing stasis and thrombogenicity within the right ventricle. The RVAD...
pump housing is placed in an extrapericardial location in the left chest, thereby avoiding compression of the RVAD into the RV at the time of chest closure. Further study and experience is necessary to confirm these advantages. In the future, RVAD pump design and implant technique should accommodate these anatomic constraints to allow consistent and reliable mechanical circulatory support of the failing right ventricle.

References