Transplant

Novel Cannulation Technique for Temporary Right Ventricular Assist Device After LVAD Placement

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Right ventricular failure is a life-threatening complication of left ventricular assist device implantation. Increasingly, right ventricular assist devices are used for compensation of postoperative right heart failure and cardiogenic shock. Currently, right ventricular assist device placement is limited by the need for delayed sternal closure, return to the operating room for removal, or restricted mobility due to a femoral venous catheter. We describe a novel technique for the placement of an extracorporeal centrifugal pump for right ventricular support that does not rely on femoral central venous access and can be discontinued in the intensive care unit after weaning of right ventricular support.

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Introduction

Left ventricular assist devices (LVAD) are increasingly used with excellent results as a bridge to transplantation or as destination therapy in advanced heart failure. However, patients who develop postoperative right ventricular failure (RVF) have higher morbidity, mortality, and resource utilization. Anticipation of postoperative RVF and placement of a temporary right ventricular assist device (RVAD) in select patients allows for compensation of cardiogenic shock acutely and may lead to improved outcomes. Among LVAD patients who develop RVF requiring mechanical support, unplanned or delayed RVAD placement is associated with worse outcomes and decreased survival to transplantation. Therefore, patients who are at risk for RVF should be identified preoperatively or intraoperatively. Several studies have identified preoperative clinical and biochemical markers of end-organ dysfunction and profiles of hemodynamic instability that predict postoperative RVF. Patients who are at risk for RVF based on the aforementioned criteria warrant consideration for planned, temporary RVAD at the time of left ventricular device insertion. Additionally, RVAD placement is appropriate for patients who have difficulty weaning from cardiopulmonary bypass due to right ventricular dysfunction at the time of LVAD placement.

Multiple techniques have been reported for simultaneous LVAD/RVAD placement but they are limited by the need for invasive access that delays recovery. Standard RVAD placement requires central access to the chest for decannulation, which necessitates either delayed chest closure or closure with repeat sternotomy at the time of discontinuation. Techniques that allow for definitive chest closure at the initial operation have also been reported but they usually rely on femoral venous catheterization for right atrial drainage. Although this configuration allows for relatively simple discontinuation in the intensive care unit, it limits mobility, thus recovery, postoperatively. In contrast, our technique for temporary RVAD placement utilizes inflow and outflow grafts tunneled through the second intercostal spaces, allowing for definitive chest closure, enhanced mobility, and increased patient comfort during RVAD weaning. In the event that the patient is unable to tolerate weaning, the RVAD can be left in place while allowing full mobility (Figs. 1–9).

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The patient is placed in the supine position with their arms tucked. After induction of general anesthesia transesophageal echocardiography (TEE) is performed to rule out aortic, mitral, and tricuspid insufficiency and to check for thrombi in the left and right ventricles or a patent foramen ovale. If valvular insufficiency is seen on preoperative echocardiography, consideration should be given to aortic valve replacement or mitral or tricuspid valve repair, as appropriate. After TEE, cardiopulmonary bypass is initiated through a median sternotomy. The arterial cannula should be placed high on the ascending aorta to leave room for the LVAD outflow graft and in anticipation of a potential transplant in the future. The venous cannula is then placed inferiorly on the right atrium in order to preserve the right atrial appendage for anastomosis to a Dacron graft that will serve as a conduit for the RVAD inflow cannula.
The left ventricular assist device is then placed in the standard fashion. Briefly, the apex of the heart is elevated and pledgeted U-stitches are placed circumferentially around the planned ventriculotomy site. The sutures are brought up through the sewing ring, which is then secured just anterior to the apex. At this point, a core ventriculotomy is performed, any thrombus is evacuated, and the inflow cannula and LVAD are placed. The outflow graft is anastomosed to the ascending aorta and the LVAD and graft are wrapped with a PTFE membrane to ease future reoperation for device discontinuation or heart transplant.
Figure 3 Patients determined to be high-risk for right ventricular dysfunction or those that do not tolerate weaning from cardiopulmonary bypass are candidates for concomitant extracorporeal right ventricular mechanical support using a Centrimag (Thoratec, Pleasanton, CA) continuous flow centrifugal pump. To facilitate the RVAD’s outflow cannula, a side-biting clamp is placed on the main pulmonary artery, an arteriotomy is made, and an 8-mm Dacron graft is anastomosed in an end-to-side fashion using a running 5-0 Prolene suture.
A similar technique is used to establish right atrial access for RVAD inflow. A side-biting clamp is placed on the right atrial appendage. The tip of the appendage is then amputated and a 14-mm Dacron graft is anastomosed in an end-to-side fashion (A). Here, the suture line is reinforced with pledgeted sutures (B).
Figure 5 The pleural spaces are entered and the right atrial and pulmonary artery grafts are tunneled up through the soft tissue and out of the skin through 2-centimeter incisions at the right and left second intercostal spaces, respectively. When tunneling the grafts through the soft tissue make sure the skin incisions are large enough that the grafts won’t be kinked or constricted and be mindful of the position of the internal thoracic artery. Also, try to exit the skin 1-2 fingerbreadths from the sternum to avoid patient discomfort.
Figure 6  RVAD cannulas are introduced through the grafts. The inflow cannula is placed into the right atrium using direct palpation and echo guidance. The outflow cannula is similarly positioned in the pulmonary artery and the grafts are secured using 0 silk ties.
Figure 7  After titration of RVAD flows the patient is weaned from cardiopulmonary bypass and the arterial and venous cannulas are removed. Hemostasis is ensured and chest tubes placed in the bilateral pleural spaces and mediastinum through linear stab incisions inferior to the sternotomy. The sternum, pre sternal fascia, and skin are then closed in the standard fashion.
Figure 8  When the patient is no longer requiring mechanical right ventricular support and their fluid status is optimized the cannulas are removed from the Dacron grafts in the ICU under conscious sedation. The grafts are then amputated at the level of the skin and over-sewn with running 4-0 Prolene sutures. The skin and soft tissue are then closed in 2 layers.
After removal of the RVAD in the ICU using minimal sedation and local analgesia the remnants of the Dacron grafts are tucked into the soft tissue, the incisions are closed, and a sterile dressing is applied. The benefits of this technique are that the chest is closed definitively after the primary operation and the patient is not exposed to additional reintubation general anesthesia, which may delay recovery. To date we have not had any thrombotic or wound complications related to the remaining graft material and have actually found that it facilitates safe dissection at the time of heart transplant.
Summary

This technique for concomitant RVAD/LVAD placement utilizes graft tunneling from the pulmonary artery and right atrium through bilateral second intercostal spaces to allow for definitive chest closure after the initial operation. In our experience, this method allows for early extubation, decreased reliance on vasoactive infusions and inhaled pulmonary dilators, and early mobility. Our method does call for 2 grafts to be left in the chest. However, the additional grafts pose a minimal risk of infection given that the patient will already require close monitoring and antibiotic prophylaxis due to the LVAD driveline. If there are concerns about complications due to the thrombosed right atrial and pulmonary artery graft, patients may be followed with serial echocardiograms. However, previous studies of abandoned pulmonary artery grafts using echocardiography have shown minimal thrombotic complications or hemodynamic effects.9

References

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