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How I Do It: Temporary RVAD Placed at the Time of Implantation of a HeartMate II LVAD

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ABSTRACT

Left ventricular assist devices (LVAD) are increasingly used to support patients as they await heart transplantation and as destination therapy for patients with end-stage cardiac failure. While the methods of LVAD implantation have become fairly standardized, early postoperative management of patients receiving these devices remains challenging. One issue that has plagued surgeons, cardiologists, and intensivists caring for patients after LVAD implantation is right heart dysfunction. While many scoring systems have been developed to try to anticipate RV failure, the accuracy of these predictive tools remains low. We present a novel approach of implantation of a temporary right ventricular assist devices (RVAD) during LVAD implantation with subsequent weaning in the immediate postoperative period, utilizing a strategy that does not require a return to the operating room for removal of the RVAD cannulas.

INTRODUCTION

Left ventricular assist device (LVAD) implantation for long-term support of the failing left ventricle has become fairly common in recent years. While the techniques for implanting these devices have become relatively standardized, the early postoperative care of the patients receiving these LVADs remains challenging. Two issues in particular have often complicated the postoperative course. These issues are the tendency for significant hemorrhage and the commonly encountered problem of right ventricular dysfunction [Patlolla 2013]. These two issues can be related. Venous hypertension in the setting of a poorly functioning right ventricle (RV) can exacerbate venous bleeding, which could contribute to tamponade physiology. And, a poorly functioning and dilated RV can be compressed by the sternum when it is closed. Occasionally, to support a failing RV, RVADs need to be implanted either intraoperatively or postoperatively. Both options have drawbacks. The intraoperative implantation of an RVAD generally mandates leaving the chest open, which increases the chance of infection of the LVAD. The LVAD, of course, needs to function for a considerable time after implantation, a need that will often be compromised if infection is present. If the need for implantation of an RVAD becomes evident postoperatively, the implant procedure often takes place under urgent and less than optimal circumstances.

Considerable attention has been given to anticipating and treating RV dysfunction after LVAD implantation. To date, no single assessment has emerged to reliably predict the need for postoperative RV support [Gaffey 2015]. The most commonly used models are the Destination Therapy Risk Score (DTRS) for first generation VADs and the Heart Mate II Risk Score (HMRS) for the more commonly used continuous flow devices [Fitzpatrick 2008; Leitz 2007]. The HMRS is used to stratify potential Heart Mate II recipients as low, moderate, or high risk for mortality based on 5 criteria: advanced age, low albumin, elevated creatinine, elevated international normalized ratio (INR), and implant center experience [Cowger 2013]. Others have suggested using cardiac index, severity of tricuspid regurgitation, RV mechanics as seen by echocardiography, pulmonary artery pulsatility index, and even MELD (Model for End-Stage Liver Disease) score to predict the likelihood of RV dysfunction after LVAD implantation [Lo 2015; De Simone 2015; Patil 2015; Kang 2014; Matthews 2010]. While there are differing opinions concerning how best to predict RV failure, it is well known that failure to anticipate inadequate right ventricular function in the early postoperative period significantly increases resource utilization, morbidity, and mortality [Kormos 2010]. Examples of the challenges posed by RV dysfunction include the need for frequent, though sometimes difficult to obtain, transesophageal echocardiography and the frequent use of inhaled nitric oxide, which remains startlingly expensive to use. Due to the uncertainty of predictive modeling some centers have reported utilizing temporary RVADs implanted at the time of the LVAD implant to circumvent RV dysfunction in the immediate postoperative period, although there is no standardized approach for their implantation, weaning, and removal [Takeda 2014; Lazar 2013; Haneya 2012]. Having faced the issues associated with RV dysfunction on a number of occasions, we developed a strategy for routine placement of an RVAD at the time of implantation of a HeartMate II LVAD. We have used this technique in 6 cases.

THE TECHNIQUE OF RVAD IMPLANTATION

We present a technique that can be used if routine implantation of an RVAD at the time of LVAD implantation is

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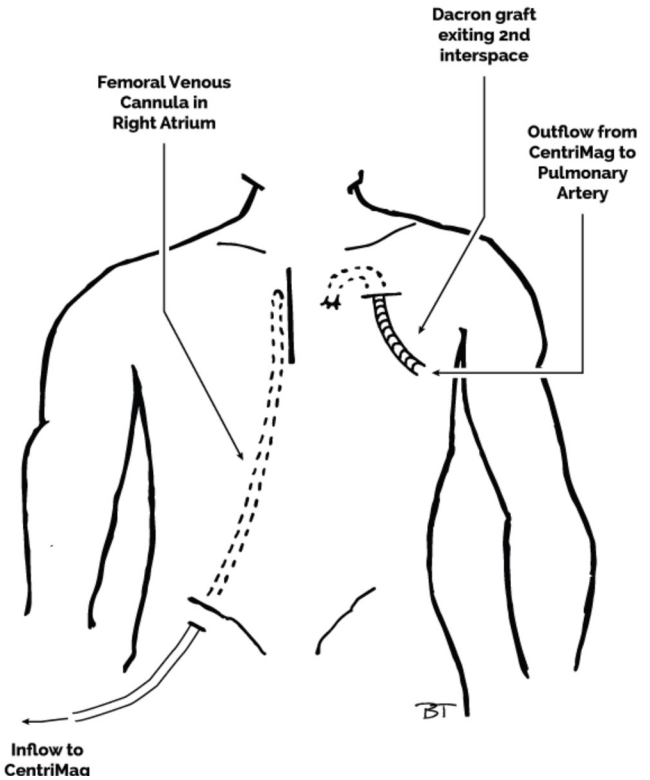

Figure 1. Schematic of femoral venous cannula providing inflow into RVAD from right atrium and Dacron graft exiting intercostal skin incision to provide arterial return to the pulmonary artery.

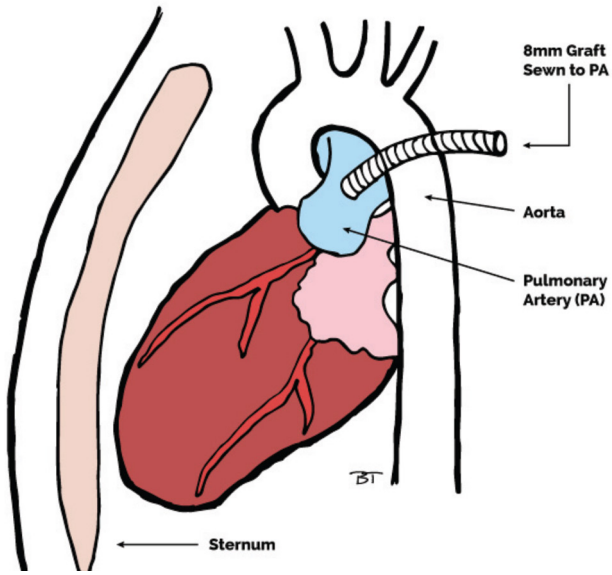

Figure 2. Dacron graft provides arterial return from RVAD to pulmonary artery.

considered. This approach was developed with the goals of making the implantation process efficient and the process of discontinuing RVAD support as simple as possible, without making reentry for the expected transplant more difficult. These goals were accomplished by the use of a percutaneous femoral venous cannula and a Dacron graft for the arterial return to the pulmonary artery tunneled through the second intercostal space and skin of the left chest. The concept of constructing a graft from a vessel to a subcutaneous position to simplify later discontinuation of mechanical support is one with which we have had experience [Buchanan 1994].

Venous inflow for the RVAD is provided by a percutaneous femoral venous line initially placed for the LVAD implant procedure, which is maintained for the duration of RVAD support. These femoral venous cannulas were placed with a micropuncture technique, followed by sequential dilatation of the track with vascular dilators and insertion of the venous cannula. The initial position of this cannula was confirmed by transesophageal echo, and the position was adjusted as necessary during the ensuing LVAD implant procedure. After the initial positioning of this cannula, a pursestring was created in the skin around the cannula entrance site using 3-0 monofilament suture. This suture was controlled with a Rummell tourniquet, which was used to stabilize the venous cannula while it was in place. This pursestring suture then was used to close the skin over the cannula entry site when the cannula was pulled later in the intensive care unit, as the only control needed for these venous insertion sites is skin closure. Placing this suture in the operating room thus aided in simplifying the eventual removal of the venous cannula. This technique for femoral venous cannula placement and removal has been employed widely in recent years. Vacuum assistance for venous drainage during the time on cardiopulmonary bypass was routinely used while the LVAD was implanted. A second venous cannula was usually placed in the right atrium to optimize drainage during this part of the case. Once the LVAD had been implanted the femoral venous cannula was shifted to the RVAD, while the right atrial cannula remained connected to the cardiopulmonary bypass circuit until the patient was weaned off cardiopulmonary bypass.

An 8mm Dacron graft was used for the arterial return to the pulmonary artery (PA). Once cardiopulmonary bypass was established, and prior to implantation of the LVAD, an aortic punch was used to create a symmetrical arteriotomy in the PA, with the goal of optimizing flow through the graft. The graft was then sutured to the PA with a running 5-0 monofilament suture. Once this anastomosis was completed, the graft was led up through a small skin incision on the left chest wall via the second interspace. Several technical issues merit attention when positioning this graft. One is that the internal mammary artery (IMA) and its accompanying veins need to be avoided. This can be done by passing a clamp through the skin incision and passing it bluntly between the sternal edge and the IMA, while visualizing the IMA from inside the chest with the sternal edge lifted by an assistant. Another point is that the pleura is kept intact in this area when feasible. The graft is clamped and left long but not

secured in place until the end of the LVAD implant procedure. The PA anastomosis and the positioning of this graft can be accomplished expeditiously.

After the LVAD implantation had been completed, the femoral venous cannula and the graft anastomosed to the PA were connected to the RVAD (a CentriMag pump, Thoratec, Pleasanton, CA, USA). The LVAD and RVAD flows were gradually increased synchronously as the patient was weaned from cardiopulmonary bypass. No inotropes were used nor was nitric oxide employed. Weaning from cardiopulmonary bypass was easily and expeditiously accomplished in all cases. Balancing flows of the two devices was guided by transesophageal echocardiography (TEE) and hemodynamic monitoring, including the monitoring of central venous and pulmonary artery pressures. The RVAD flows were adjusted to partially decompress the right ventricle and to appropriately deliver volume to the LVAD.

Drains were placed in the pericardium, the pleural spaces, and the LVAD pocket and the chest was closed in a standard fashion. As usual, as much autogenous tissue as possible was positioned over the heart, the LVAD, and the LVADs conduits. This tissue was frequently supplemented with prosthetic material to facilitate later reentry for the expected explantation of the LVAD at the time of cardiac transplantation.

Anticoagulation strategy was not altered when these RVADs were used. In brief, the transition to full anticoagulation in the early postoperative period was guided by how quickly the chest tube drainage subsided. In general, antiplatelet therapy with aspirin was resumed first, usually on the first postoperative day. Subcutaneous heparin was usually added on the second postoperative day. Coumadin was usually started by the third postoperative day. Full anticoagulation with continuous infusion of heparin was not commonly used, though it was used if the INR did not rise in the early days after starting coumadin. At least some of the chest tubes were left in place until the level of anticoagulation was nearing the goal level.

Each day after the implantation of the VADs, with TEE guidance, the RVAD flows were lowered to gauge the ability of the right ventricle to deliver blood to the LVAD. The patient was kept sedated. Generally, the RVAD support was discontinued by the second or third postoperative day, usually without the need for nitric oxide. When it was clear that the support of the RVAD was no longer needed, disconnecting the RVAD was quite simple. Removing the femoral venous cannula was accomplished by pulling the cannula and tying the previously placed pursestring. After instillation of local anesthetic in the skin, the Dacron graft exiting in the second interspace was clamped with a vascular clamp and excess graft material was cut off. The graft was then oversewn in two layers with a single 4-0 monofilament suture. The residual graft material was allowed to retract into the intercostal muscle of the second interspace. The skin was closed in two layers with absorbable suture. No bleeding or complications were noted at either site in any of the patients managed in this way. No other untoward sequelae were noted at either site at any point. At the time of this report, five of the patients managed in this manner have been transplanted. The residual Dacron graft did not pose any significant technical issues at the time of the transplant, and most of the residual graft material was removed without difficulty at the time of LVAD explantation for transplantation.

DISCUSSION

This strategy of implanting a temporary RVAD aided in weaning from bypass at the time of the LVAD implant. The expense of perioperative nitric oxide was avoided in all cases. Bleeding after the implant operation seemed to be less of an issue than in many prior cases done without RVAD support. The chest was closed securely in all patients in the primary operation. No patient required reexploration.

Conclusion

This straightforward technique may be attractive for use in patients with biventricular failure who require LVAD support, as well as in situations in which the postoperative critical care support system is expected to be less robust than might be considered ideal.

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