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A Technique for Implantation of the CentriMag Left Ventricular Assist Device to Allow Ambulation and Rehabilitation in Patients with Heart Failure

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ABSTRACT

Background: The therapeutic options for heart failure include inotropic agents, intraaortic balloon pumps, and left ventricular assist devices (LVAD). Implantable LVADs are not appropriate for all patients. The short-term devices require patients to stay in bed, connected to cannulas, which are usually inserted using a median sternotomy. This approach requires a subsequent sternotomy, midline cannulas (which can make sitting difficult), and immobility. We began using a right thoracotomy with cannulas placed through intercostal spaces for selected patients in need of temporary LVAD support.

Methods: This retrospective chart review examined our experience with CentriMag LVAD placement via right thoracotomy from August 2009 to June 2013. We reviewed the reasons for support, the degree of postoperative mobilization, and the outcomes of the patients treated in this manner.

Results: This approach was used in 6 patients. Four patients lacked financial or social support for a long-term, implantable LVAD. One patient was considered too ill to have an implantable LVAD placed, and one was treated with temporary support with hope for recovery from myocarditis. Five of these 6 patients were able to walk soon after LVAD implantation and initiate rehabilitation. One did not recover and had support withdrawn. Another suffered a stroke and had support withdrawn. Four of the 6 were transplanted successfully.

Conclusions: CentriMag LVAD implantation via a right thoracotomy is a feasible approach that provides adequate hemodynamic support while allowing patients to ambulate, making subsequent cardiac transplantation less complicated by allowing the avoidance of a repeat sternotomy.

INTRODUCTION

The therapeutic options for decompensated heart failure include inotropic agents, intraaortic balloon pumps (IABP), and, in selected cases, left ventricular assist devices (LVAD), which include both short-term, external devices and long-term, implantable devices. Implantable LVADs are not appropriate for all patients for a variety of reasons. The short-term devices typically require that the patient stay in a hospital bed, as they are usually connected to cannulae that are inserted using a median sternotomy, exit through the upper abdominal muscles, and are, therefore, difficult to stabilize safely. This arrangement has the additional disadvantages of requiring a sternotomy (which mandates a redo sternotomy later), midline cannulae (which can make it difficult for patients to sit up), and immobility (with all the attendant risks of being bedridden). Inspired by a case report of a patient in which a temporary LVAD was implanted using a right thoracotomy, with cannulae placed through intercostal spaces, we began using this approach for selected patients in need of temporary circulatory support [Gregoric 2008].

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MATERIALS AND METHODS

This report is based on an observational, retrospective chart review. After approval by the Institutional Review Board at the University of Mississippi Medical Center, we reviewed our institution's LVAD data set and analyzed patients who underwent the implantation of a CentriMag LVAD as a bridge to decision, bridge to recovery, or bridge to transplantation, from August 2009 to June 2013. We analyzed the patients' outcomes with a focus on the degree of their mobility after the insertion of the LVAD, as well as noting the reasons for choosing this approach, the complications, and the eventual outcomes. We included in this study only patients who underwent a right thoracotomy for the insertion of this type of LVAD during the study period.

Operative Technique

The patients were positioned so that they were tilted up about 30 degrees, to facilitate a right anterior thoracotomy. Monitoring included a radial arterial line, a Swan-Ganz catheter, and a transesophageal echocardiography probe. The patients were intubated with a single lumen tube.

A right inframammary incision was made and carried down through the pectoralis fascia to the chest wall. Dissection was then continued underneath the pectoralis muscle up to the 4th intercostal space where the pleural space was entered. The lung was retracted with moist pads to expose the pericardium, which was opened and tacked to the skin edges to pull the heart slightly towards the right and to hold the lung out of the operative field. Waterston's groove was dissected to allow access to the roof of the left atrium medial to the right pulmonary veins. The pericardium was opened superiorly far

enough to allow comfortable access to the mid-portion of the ascending aorta.

We used 32 to 36 mm venous cannulae and 8 to 10 mm aortic cannulae, depending on the size of the patient. A 2-0 purse-string of braided suture was placed in the left atrium and a similar 2-0 purse-string suture was used for the aorta. The two cannulae were passed through separate spots in an intercostal space below the thoracic incision with the exit sites being approximately in the anterior axillary line. These cannulae were passed through the lower chest wall prior to insertion into the left atrium and the aorta, to minimize the possibility of dislodging the cannulae after cannulation of the respective sites. At this point a loading dose of heparin, analogous to a cardiopulmonary bypass dose that would be used for each patient, was given.

After insertion into the chest cavity and before insertion into the left atrium and aorta, each cannula was inserted in a Dacron graft of slightly larger diameter than the cannula. A small cruciate cut was made in the atrium with a pointed scalpel and dilated with a cow's horn dilator. This dilator was exchanged for the venous cannula which was positioned so that the tip was just inside the roof of the atrium. The purse-string suture was tied down but not cut. This braided suture was then pulled through the Dacron graft to lie between the cannula and the graft to aid in stabilizing the cannula. The distal end of the Dacron graft was then sutured in a continuous running fashion to the anterior wall of the atrium with a 5-0 polypropylene suture to aid in hemostasis around this site. Several heavy ligatures were tied around the graft, the braided suture, and the cannula, both for purposes of hemostasis and for stability [Wyatt 1993].

To cannulate the aorta, we used the Seldinger technique. We inserted a needle through the purse-string suture into the aorta, passed the wire through it, and then pulled the needle out over the wire. The wire was then fed back through the dilator inside the arterial cannula. The cannula was then inserted into the ascending aorta, and the purse-string suture was tied. Once again, the braided suture of the purse-string was pulled out through the Dacron graft so that it would lie between this graft and the cannula. The distal end of this Dacron graft was then stitched to the adventitia of the aorta, outside the purse string, with a running 5-0 Prolene suture.

Two Blake drains were positioned near the cannulation sites and brought out of the chest through an intercostal space below the skin incision, slightly anterior to the exit sites of the cannulae. The cannulae were stitched to the skin and attached to the CentriMag device. The LVAD was turned on and flows adjusted appropriately.

To close the chest we drilled holes in the rib below the 4th intercostal space and passed #2 Vicryl sutures through these holes and ran them around the rib above to avoid intercostal nerve compression. The muscles, subcutaneous tissues, and skin were closed with absorbable sutures. The cannulae were further stabilized on the lower chest wall with adhesive devices commonly used to stabilize Foley catheters in ambulatory patients.

All patients were started on a heparin drip at 1,000 units/hr, seeking to achieve an activated clotting time (ACT) goal between 200 to 220 seconds and a partial thromboplastin time (PTT) between 1.5 to 2.5 seconds. We monitored PTT and platelet count daily, and ACT twice a day with the ACT being considered the most accurate gauge of the degree of anticoagulation.

RESULTS

During the study period, 10 patients were supported with CentriMag LVADs. Four of these 10 had their ventricular assist device (VAD) placed via median sternotomy while the other 6 were placed using a right anterolateral thoracotomy. The largest patient in this series who had his VAD placed via a right thoracotomy required an additional median sternotomy in order to gain access to the aorta, which proved in this case to be difficult to access safely from the right chest due to the patient's very large size. This patient still had the cannulae led out the right chest once the aorta had been cannulated successfully. Of those who had a right thoracotomy for the LVAD insertion, 5 were males, and 1 was female. The average age of these 6 patients was 35.8 years old (range: 18 - 56 years old). The average time they were supported with the LVAD was 39.6 days (range: 18 - 94 days; median: 27 days). A brief summary of indications, recovery, and outcome is provided in the Table.

Patients' Summary

Indication for VAD	Timing of Ambulation	Complications	Eventual Outcome
Bridge to recovery (myocarditis)	Postop day 8	Transient ischemic attack	Transplanted: Postop day 47
Lack of funding, bridge to transplant	Postop day 5	Cardiac enzyme rise	Transplanted: Postop day 18
Lack of funding, bridge to transplant	Postop day 3	Hemothorax	Transplanted: Postop day 94
Lack of funding, bridge to transplant	Postop day 3	None	Transplanted: Postop day 25
Lack of family support, bridge to transplant	Postop day 2	Stroke	Support withdrawn: Postop day 37
Bridge to decision	Did not recover	Retroperitoneal hemorrhage, CVA	Support withdrawn: Postop day 27

CVA indicates cerebrovascular accident; VAD, ventricular assist device.

DISCUSSION

There are 2 primary types of LVADs, the permanent (implantable) devices, like the HeartMate II, and the temporary (external) devices, like the CentriMag. The temporary devices are usually placed using a median sternotomy approach and, generally, require that the patient remain at least relatively bed-bound, with all the morbidities and incapacitation that this involves [Camp Jr 2013]. This degree of immobility is considered necessary because the cannulae exiting in the upper abdomen cause discomfort, especially while trying to sit up, and because of concern about movement dislodging the cannulas from the heart and aorta. Another consideration is that a median sternotomy will, of course, require repeat sternotomy at the time of heart transplantation, with its attendant concerns [Tsiouris 2013]. Some temporary ventricular assist devices are also set up using groin cannulation, which, of course, necessitates keeping the patient supine.

In an attempt to address these issues, Takayama et al used a technique for cannula stabilization in one patient in whom a median sternotomy was used for the implant, which allowed their patient to ambulate after a period of recovery [Takayama 2011]. They led the cannulae out through the upper abdomen. They stabilized these cannulae by affixing them to the exit sites on the posterior aspect of the rectus abdominis muscle fascia in hopes of preventing migration during physical activity. This approach was successful but did require a median sternotomy (and, thus, a repeat sternotomy for transplantation) and required placing the large cannulae through the upper rectus muscles.

Gregoric et al from the Texas Heart Institute performed a right thoracotomy through the 4th intercostal space to insert a CentriMag LVAD in a patient who required mechanical ventricular support 8 days after a coronary artery bypass operation [Gregoric 2008]. This approach was utilized, recognizing that access to the aorta, left atrium, and mitral valve was feasible and would avoid the need for a repeat sternotomy in this setting [Tribble 1987].

Bleeding from the insertion sites of cannulae is a common problem after temporary cannulation for mechanical circulatory support. This bleeding has been found to occur secondary to shifts of the position of the cannula, gradual loosening of the purse-strings, or tearing of the thin atrial wall. In order to decrease bleeding around such temporary cannulas, we used a Dacron cuff placed over the cannulae and sewn to the surface of the structure into which the cannula had been placed [Wyatt 1993].

In conclusion, the implantation of the CentriMag LVAD, as a bridge to recovery, bridge to decision, or bridge to transplantation, utilizing a right anterolateral thoracotomy is a feasible and relatively safe option. This approach obviates the need for a redo-sternotomy for transplantation, which may expedite this subsequent operation. The right thoracotomy approach also allows the patient to ambulate and participate in rehabilitation while awaiting transplantation and may be useful in some situations in which temporary LVAD support is indicated.

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