Tips on Tuning Each Device: Technical Pearls

Hiroo Takayama, MD, Jonathan A. Yang, MD,
Yoshifumi Naka, MD, PhD*

KEYWORDS

• Implantation technique • HeartMate XVE • HeartMate II
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Significant improvement has been made in ventricular assist device (VAD) technology, and this has led to an expanding use of this technology in various scenarios in which a patient suffers from end-stage heart failure (HF). VADs work as an extra pump to support circulation. These devices consist of an inflow, through which the blood is drained from the native circulation; a pump; and an outflow, through which the blood is returned back to the patient. Although simple in concept, successful implementation of this technology requires appropriate experience and substantial up-to-date knowledge regarding best practices for surgical technique and management, which go far beyond just understanding the basic mechanics. One of the most important aspects of patient care associated with VADs is the surgical technique at implantation. Technical pitfalls that have been identified over the years are described for each device with a focus on implantable long-term left VADs (LVADs). In addition to the devices discussed in this review, there are other devices that are or will soon be undergoing clinical trial but are beyond the scope of this review.

GENERAL SURGICAL TECHNIQUE OF LONG-TERM LVAD IMPLANTATION

It will be useful to describe the general technique of LVAD implantation because most of the steps are shared for many implantable LVADs.

A vertical midline incision is made with extension onto the abdominal wall. After standard median sternotomy, a pocket of an appropriate size is created in the preperitoneal space in the upper abdomen.[1] If the preperitoneal plane is very thin and attenuated, the posterior rectus sheath is entered and a plane superficial to this is developed. The device is positioned in the preperitoneal pocket, and the driveline is tunneled. After systemic heparinization, the patient is cannulated for cardiopulmonary bypass. If the hemodynamic status permits, the outflow graft anastomosis is performed off-pump using a partial occluding clamp placed on the ascending aorta. Cardiopulmonary bypass is initiated, and the left ventricle (LV) is decompressed by placing a vent through a stab wound at the LV apex. For reoperative LVAD implantation, the posterior pericardial space is dissected out just enough to elevate the apex to sew the inflow cuff (**Fig. 1**). As bleeding from this area can be significant after reoperative LVAD implantation, careful hemostasis is crucial. The LV apical core is excised with a specialized coring knife. Care must be taken when coring to avoid deviation into the septum or the lateral wall. Any excess trabeculations or myocardium that may obstruct the inflow cannula is excised, as well as ventricular intramural thrombus. The inflow cuff is secured to the edges of the core with 2-0 braided polyester sutures reinforced with felt pledgets and then attached to the inflow

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Department of Surgery, Columbia University Medical Center, Milstein Hospital Building, 7-435, 177 Fort Washington Avenue, New York, NY 10032, USA
* Corresponding author.
E-mail address: yn33@columbia.edu

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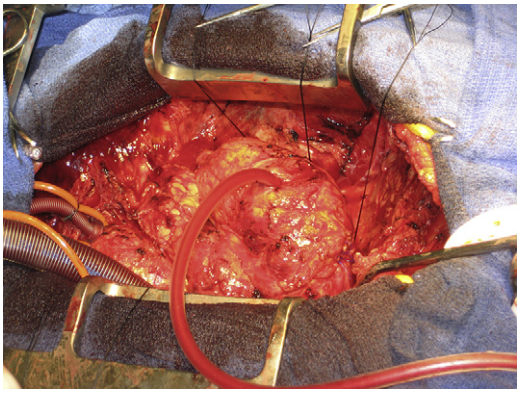

Fig. 1. Exposure of the left ventricular apex for reoperative LVAD implantation. The apex is elevated with several deep pericardial stitches. A vent is inserted through a stab wound at the apex for decompression.

cannula of the device. For fragile myocardium, this suture line is reinforced with a strip of Teflon felt (**Fig. 2**). The heart is allowed to fill with blood, and the device is deaired through a venting hole placed in the outflow graft. Evacuation of air is confirmed with transesophageal echocardiogram (TEE). The patient is then weaned from cardiopulmonary bypass, and the device is initiated.

PREPARATION FOR RESTERNOTOMY

Not just a small subset of patients with an LVAD requires another sternotomy for reasons such as heart transplantation or device exchange. Sternal reentry after a VAD implantation is challenging because development of dense adhesions around the heart and the device is usually the case. At the time of LVAD implantation, the surgeon is responsible for anticipating the possibility of a future cardiac operation. The same principles used during other cardiac surgery are followed for the prevention of postoperative bleeding and infectious complications, thus reducing the formation of adhesions.

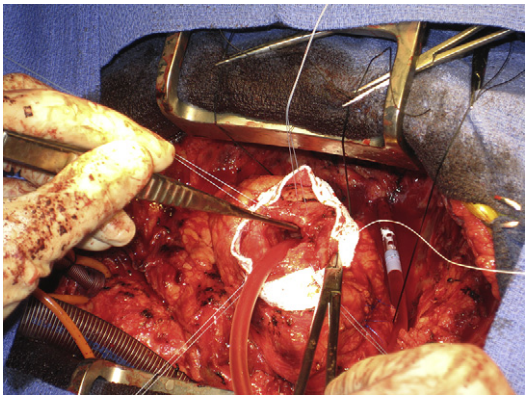

Fig. 2. For fragile myocardium, the suture line for inflow cuff placement is reinforced with a strip of Teflon felt.

In addition, to reduce the difficulty in performing repeat sternotomy, several measures are implemented in our program. Various membranes have been tried to protect the underlying cardiovascular structures on sternal reentry. We used to place a piece of thick polytetrafluoroethylene patch between the anterior surface of the heart and the sternum. However, this technique resulted in adhesions between the patch and the sternum, which can deceive surgeons at sternal reentry who perceive it to be the posterior plate of the sternum. In addition, the technique also creates tight adhesions with the heart. Thus, we abandoned this material as “a recipe for disasters.” Until recently, the most commonly used material at our institution was a thin expanded polytetrafluoroethylene membrane. This pericardial substitute has been reported to be safe and effective in reducing the risk of sternal reentry for various types of cardiac reoperations, including those after VAD implantation, although in patients who underwent reoperation, the underlying epicardium and coronary vessels were sometimes obscured by a film of fine adhesions.[2,3] Another option is to use an extracellular matrix (ECM) membrane. Recently, with advancements in tissue engineering, elements of the ECM have gained increasing attention as crucial elements in maintaining the characteristics of 3-dimensional cardiac cell aggregates.[4] ECM, once regarded as merely a scaffold for developing tissue, plays an important role in providing essential signals that influence major intracellular pathways such as proliferation, differentiation, and cell metabolism. One of the synthetic ECM products, CorMatrix (CorMatrix Cardiovascular, Inc, Alpharetta, GA, USA), is made from sterilized and decellularized porcine small intestinal submucosa. When used to reconstruct pericardium, this product allows cells to infiltrate the ECM to remodel and form a new pericardial layer. The CorMatrix has gained attention and is increasingly used in clinical practice. We have used this product for pericardial reconstruction after a VAD implantation and have experienced its satisfactory antifibrotic property at subsequent VAD-explant heart transplantation (based on authors anecdotal clinical experience). The edge of the CorMatrix is secured to the edge of the opened pericardium with a 4-0 polypropylene running suture to cover the entire heart and inflow and outflow conduits. At reoperation, it is common to find some adhesions between this tissue and the underlying heart, but it is usually very easy to define the edge of the pericardium, and