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Surgical Considerations for Left Ventricular Assist Device Implantation

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Introduction

This article summarizes the perspective from Baylor College of Medicine and The Texas Heart Institute on the key surgical considerations for ensuring a successful outcome after left ventricular assist device (LVAD) implantation.

Currently, the HeartMate 3 (Abbott Cardiovascular) is the only US Food and Drug Administration–approved durable LVAD on the market (Fig. 1).[1] The HeartMate 3 is an excellent device associated with good long-term survival, with 5-year survival at 58.4% compared with 43.7% for the HeartMate II in the most recent landmark analysis (Fig. 2).[2] Significant progress has been made regarding LVAD circulatory system complications, and the latest generation of devices has decreased the incidence of pump thrombosis, bleeding, and thromboembolic complications.

Operative Technique

Median sternotomy and lateral thoracotomy are 2 options for operative exposure. Median sternotomy is favored for several reasons. The Texas Heart Institute has a dynamic patient population with increased risk for right ventricle

Fig. 1 Left ventricular assist device system components. HeartMate, HeartMate II, MOMENTUM 3, and HeartMate 3 are trademarks of Abbott or its related companies. Reprinted with permission of Abbott (Copyright ©2023). All Rights Reserved.

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(RV) dysfunction, valvular issues, coronary disease, and reoperations. Median sternotomy provides the greatest exposure to important cardiac structures that may be needed to maximize cannulation options. Anecdotally, postoperative pain for a sternotomy is comparable to if not better tolerated than that for a thoracotomy. The lateral thoracotomy incision has a role in patients without valvular disease and a large left ventricle or patients with preexisting bypass grafts.

Cardiopulmonary bypass (CPB) is an important element of the LVAD operation and allows the surgeon to manipulate and empty out the heart. Without CPB, there is increased risk of air embolism and ventricular tears resulting from insufficient decompression of the heart. While the patient is on CPB, the aim is to keep the mean arterial pressure elevated and CPB time low. A recent single-center study from Baylor College of Medicine and The Texas Heart Institute looked at the effects of bypass time on LVAD outcomes (data not published).

Abbreviations and Acronyms

CPB	cardiopulmonary bypass
LVAD	left ventricular assist device
PA	pulmonary artery
RV	right ventricle

Cardiopulmonary bypass time was independently associated with increased operative mortality, reoperation for bleeding, and tracheostomy. The results are predictable but important; the surgeon should carefully evaluate the risks and benefits before any additional procedures during LVAD insertion.

There are various options for the inflow placement of the LVAD device. A minicuff can be used in the inferior surface lateral to the posterior descending artery. The anterolateral approach has recently been adopted, whereby the inflow sewing cuff is sewn to the anterolateral surface of the left ventricle with interrupted 2-0

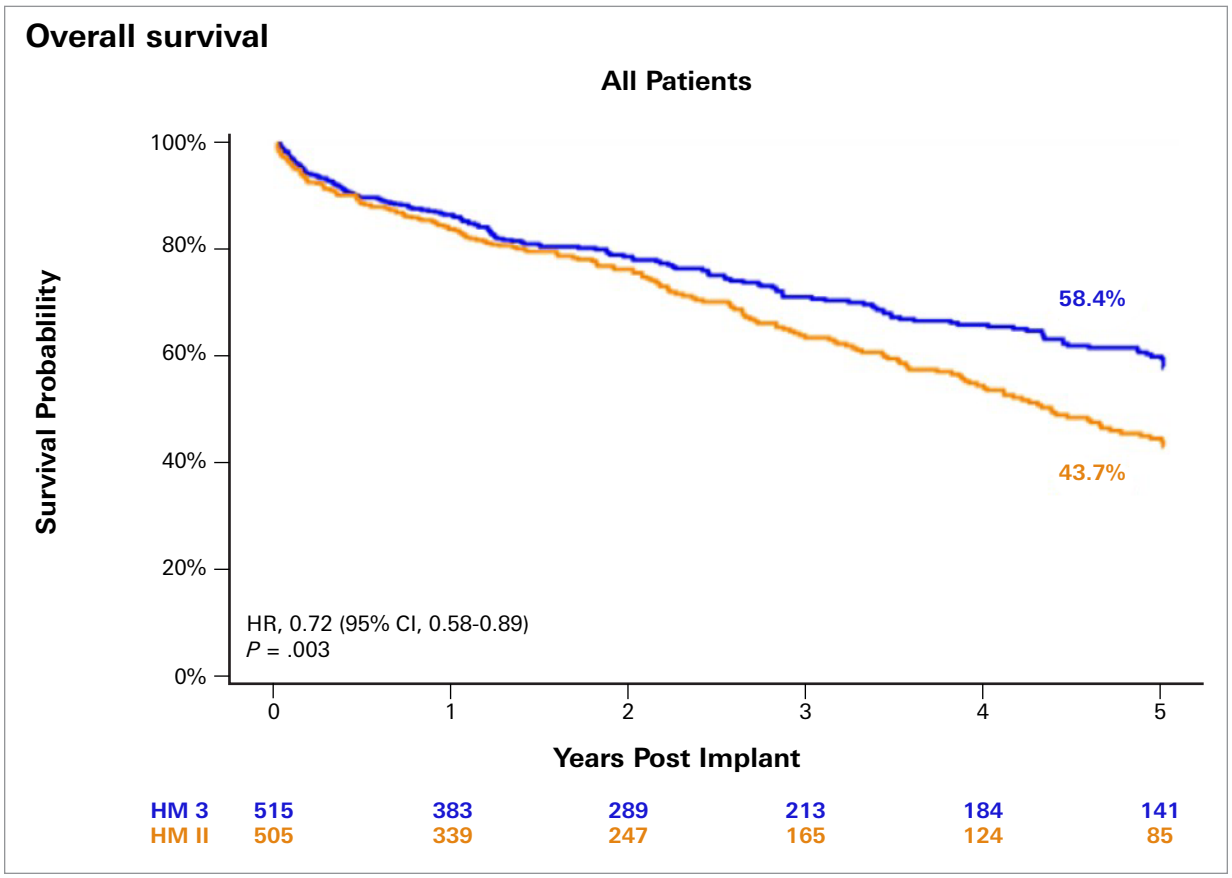

Fig. 2 Kaplan-Meier survival curve showing statistically significant overall survival with HeartMate 3 vs HeartMate II. HeartMate, HeartMate II, MOMENTUM 3, and HeartMate 3 are trademarks of Abbott or its related companies. Reprinted with permission of Abbott (Copyright ©2023). All Rights Reserved.

pledgeted sutures. This location aligns the inflow cannula well with the mitral valve, which is a key element of device implantation. The LVAD outflow graft must be sized to the ascending aorta to ensure that there is no kinking or twisting. It is sewn using a running 4-0 Prolene suture (Ethicon Inc) with a side-biting clamp. After completing the LVAD outflow graft anastomosis to the aorta, meticulous attention is required to remove air from the LVAD and the left ventricle using an aortic root vent and direct needle puncture of the outflow graft.

A common question is whether intervention for valvular disease is necessary during LVAD implantation. The key consideration is the risk-benefit ratio involved with increasing the CPB time. For instance, mitral and tricuspid valve regurgitation often improves over time with LVAD implantation alone. Adding time may increase the operative risk, but if the valves are addressed expeditiously, there may be postoperative hemodynamic benefits for individual cases.[3]

Hemodynamic Assessment

Upon initiation of the LVAD, the interventricular septum shifts to the left side, and inflow into the RV increases. Right ventricular afterload increases as pulmonary vascular resistance is elevated because of combined precapillary and postcapillary pulmonary hypertension, which is a setup for RV failure. Right ventricle failure occurs in 5% to 20% of LVAD cases and is defined by elevated central venous pressure and low pulmonary artery (PA) pressure.[4] Preoperatively calculating a PA pulsatility index is useful to help determine the risk of RV dysfunction after LVAD implantation (PA pulsatility index = PA systolic – PA diastolic / central venous pressure). If the PA pulsatility index is less than 1.85 preoperatively, there is significant risk for RV dysfunction, and consideration should be given for right ventricular assist device placement.[4] For patients at risk for RV dysfunction after LVAD implantation, early initiation of RV support results in improved survival.[5]

Conclusion

Increasing the LVAD flow rate slowly, being judicious with fluids, and having pulmonary vasodilator and inotropic support can reduce the incidence of RV failure requiring right ventricular assist device implantation. When needed, a temporary right ventricular assist device can be easily implanted.[6,7]

Future Directions

Several important surgical considerations can help ensure a successful outcome after LVAD implantation. Many new and exciting devices are on the frontier, several of which are being pioneered here at Baylor College of Medicine and The Texas Heart Institute. Over time, likely in this generation, the LVAD modular cable will disappear, and the LVAD will evolve into a battery-powered device, with direct control from an external wireless device.

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