Masters of Cardiothoracic Surgery

Technique for implantation of HeartMate II left ventricular assist device with concurrent mitral and tricuspid valve repair

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Submitted May 10, 2014. Accepted for publication Aug 19, 2014.
doi: 10.3978/j.issn.2225-319X.2014.08.11
View this article at: http://dx.doi.org/10.3978/j.issn.2225-319X.2014.08.11

Clinical vignette

A 50-year-old male with end-stage cardiomyopathy had been on the transplant waiting list as UNOS status 1b and was recently admitted to hospital with decompensated heart failure (*Video 1*). His recent transthoracic echocardiogram showed dilated left ventricle with severe dysfunction, severe mitral valve regurgitation and severe tricuspid valve regurgitation. He was in INTERMACS class II and was referred for mechanical circulatory support as a bridge to transplant.

Surgical technique

Patient preparation and intraoperative transesophageal echocardiogram

The patient was placed in supine position and percutaneous defibrillating pads were placed. An arterial line was inserted and general anesthesia was administered with endotracheal intubation. A pulmonary artery catheter was floated and a Foley catheter was inserted.

A transesophageal echocardiogram was performed. There was no patent foramen ovale or left ventricular (LV) thrombus. LV function was severely depressed and there was moderate right ventricular dysfunction. There was no aortic insufficiency, but severe mitral and tricuspid regurgitation was detected.

Potential driveline exit site was marked on either side, two fingers below the costal margin in the midclavicular line. The patient was prepped and draped in a strict sterile fashion.

The HeartMate II left ventricular assist device (LVAD) was prepared according to manufacturer recommendations.

Median sternotomy and pocket formation

A median sternotomy was performed with the skin incision extending just below the tip of the xiphoid process. The pericardium was opened vertically, preserving the thymic remnants and mediastinal fat. The lower end of pericardiotomy was extended transversely to the LV apex. An internal mammary artery retractor was placed to elevate the left hemi sternum. A pre-peritoneal pocket was then created: the costal attachments of the diaphragm were first divided with cautery and the plane between the peritoneum and abdominal muscles was opened with careful cautery dissection to create a large pocket for the ventricular assist device. The lateral extension of the pocket was formed just beyond the level of the LV apex. The left pleural space is often entered in this process. The pocket was extended slightly to the right of the midline. Meticulous hemostasis is critical during this time. A HeartMate II sizer was placed in the pocket to confirm adequacy of the pocket size.

Driveline

The primed LVAD pump was brought into the operating field. The driveline was screwed to the HeartMate II driveline tunneler. Using the tunneler, the driveline was tunneled from within the right most aspect of the pocket, through the rectus muscle and subcutaneous fat, to exit the skin though a transverse incision in the right subcostal area. The tunneler was reinserted and directed leftwards within the abdominal wall and exteriorized through the previously marked site in the left subcostal region. An umbilical tape was placed around the driveline at the first exit site so it would not be lost inside the abdominal wall (1). The tunneler was detached and the driveline was inserted into the system controller. The pump was then wrapped in a sterile towel and secured temporarily to the drape over the lower abdominal wall.

Cardiopulmonary bypass (CPB)

A pericardial well was created by lifting the pericardium on

the right side and superiorly. A self-retaining atrial retractor was then placed with the horizontal bar towards the head. An epiaortic ultrasound was performed to assess the ascending aorta. The patient was systemically heparinized. The ascending aorta was then cannulated distally, leaving enough room for the outflow graft anastomosis. Direct superior and inferior vena caval cannulation was performed and CPB was established with mild systemic hypothermia (34 ℃).

Inflow cannula placement

The patient was placed in the Trendelenburg position. The pericardial well was insufflated with carbon dioxide. Multiple laparotomy pads were placed behind and lateral to the LV to displace the LV apex into the operating field. The heart was temporarily filled with blood by partial occlusion of the venous drainage tubing. The cylindrical coring knife was used to punch out a hole in the LV on the anterior surface of the LV near the apex and lateral to the left anterior descending artery. The direction of coring was slightly away from the septum, pointing towards the mitral valve. The knife was withdrawn; blood volume was taken back in CPB circuit and was sucked with cardiotomy suckers. The cored piece of the LV was completely excised and sent for histopathological examination. The LV cavity was inspected for any thrombi. Trabeculae and bands that could potentially obstruct the inflow were excised. Electrocautery was used to perform hemostasis on the cored margin. During this process the heart was intentionally allowed to fibrillate. Using a marking pen, four quarters were then marked on the LV surface around the ventriculotomy. The sewing cuff was also marked and divided into eight equal parts. Eight 2-0 polyester sutures with large teflon pledgets and a MH needle were used in a horizontal mattress fashion. These sutures were passed 'outside-in' in the LV, 2 to 3 cm from the ventriculotomy edge and passed backwards 'inside-out' taking 2-3 mm thickness at the edge of the ventriculotomy, before being passed through the sewing cuff of the inflow conduit of the HeartMate II device (2). The cuff was lowered and the sutures were tightened securely. The CPB flow was reduced to 500 cc/min and coseal (baxter healthcare corporation) was placed along the suture line for hemostasis. The inner plastic tubing was removed, the CPB flow was increased back to full flow after 30 seconds and a cardiotomy suction was placed inside the LV. The lap pads were then removed from the pericardial sac.

Mitral and tricuspid valve repair

Umbilical tapes were passed around the vena cavae, which were snared. The right atrium was opened parallel to and away from the atrio-ventricular groove. Stay sutures were placed to retract the edges of the atriotomy. The interatrial septum was incised in the lateral side of the fossa ovalis and the incision was extended vertically. The mitral valve retractor system was then placed and the mitral valve was analyzed. Typically one would see leaflet tethering from ventricular dilatation. Mitral valve annuloplasty was performed with a Carpentier-Edward Physio ring (Edwards Lifesciences) applied with interrupted 2-0 polyester sutures placed circumferentially around the annulus in mattress fashion. The interatrial septum was then closed with 3-0 polypropylene suture with a SH needle. The tricuspid valve annuloplasty was performed with an incomplete rigid Carpentier-Edward Physio ring (Edwards Lifesciences) applied with interrupted 2-0 polyester sutures placed circumferentially around the tricuspid valve annulus in mattress fashion. The right atrium was then closed.

Inflow attachment

Ventilation was resumed temporarily and the heart was filled with blood. The HeartMate II LVAD pump was brought into the operative field. The inflow limb of the LVAD was introduced into the LV through the inflow conduit and was tied with the attached polyester suture, and two #5 silk ligatures for additional security. A cardiotomy suction was attached, with a 1/4 inch perfusion adapter, to the outflow limb of the LVAD, and low suction (50 mL/min) was initiated. The LVAD pump was placed in the pocket.

Outflow graft placement

A 'Lambert-Kay' side-biting clamp was placed on the ascending aorta (slightly to the right and as proximal as possible to leave more distal aorta for the transplant and taking care to avoid right coronary artery origin), after temporarily reducing the CPB flow. A longitudinal aortotomy was made with a 11 no. scalpel for about 1 cm and the margins were cored out with a punch to make an adequate opening measuring about 18 mm in length.

The outflow graft was stretched from the level of the diaphragm to just above the aortotomy and divided at this level. A Gore-Tex tube graft (16 mm × 20 cm trimmed to length) was placed outside the outflow graft to afford protection at the time of re-entry. The outflow graft, along with the outer Gore-Tex graft (Gore-Tex), was sutured to the aortotomy with a 3-0 RB prolene suture in a continuous fashion. The suture was tightened with a nerve hook and tied. A vascular clamp was applied to the outflow graft and the Lambert Kay clamp was

released by temporarily reducing the CPB flow. By releasing the clamp momentarily, free blood flow from the aorta into the outflow graft was ensured. This part of the operation can be performed as the first step of LVAD implantation sequence, before instituting cardiopulmonary bypass.

De-airing, weaning from cardiopulmonary bypass (CPB)

A needle vent was inserted into the ascending aorta and the heart was defibrillated. The LV and the LVAD were de-aired by resumption of ventilation and partial occlusion of the venous line. The outflow graft of the LVAD was then articulated with the main pump.

A 5-0 polypropylene purse string was placed on the outflow graft and the LVAD pump was initiated at 6,000 revolutions per minute (rpm). Deairing was performed through a hole in this purse string with a 18-gauge needle. By moving the clamp onto the outflow graft, deairing was performed from both LV and aortic sides. The clamp was removed and the purse string was tied after adequate de-airing.

Moderate inotropes were started and epicardial atrial pacing was initiated. Device support was increased with incremental pump speeds of 8,000 and 9,000 rpm while the CPB flow was weaned off accordingly. Echocardiography confirmed satisfactory placement of the inflow cannula and the midline position of the interventricular septum. The heparin was reversed with protamine and the patient was decannulated.

Securing the outflow connection and LVAD position

The 'Bend relief' was then secured to the pump and the retaining collar was applied to prevent disconnection and secured with two horizontal mattress sutures (3). The device was secured to the rectus sheath with a strong polydioxanone suture to prevent migration (4).

Closure

Hemostasis was established in all the surgical sites. Blake drains were placed within the pericardium, pump pocket and anterior mediastinum.

The anterior pericardium was reconstructed with expanded polytetrafluoroethylene ("Gore-Tex") membrane.

The sternum was re-approximated with stainless steel wires and the soft tissues were closed with absorbable sutures. The exit site of the ventricular assist device was repaired such that some of the veloured portion lay outside the abdominal wall.

The patient was transferred to the intensive care unit in a stable condition.

Comments

Recently we have adopted sternal sparing techniques when no concomitant valve procedure is needed (5). This sternotomy approach is used in cases, such as this, where repair of cardiac valves is planned. We also use the sternotomy approach for reoperations. We prefer to correct moderate or greater tricuspid regurgitation with valve repair (6). We also correct severe mitral valve regurgitation with valve repair. More than mild aortic insufficiency is corrected with a 'Park suture" closing the aortic leaflets together (7). Similar technique is employed for placement of other implantable ventricular assist devices.

Acknowledgements

Disclosure: The authors declare no conflict of interest.

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Cite this article as: Pawale A, Plotkina I, Anyanwu AC. Technique for implantation of HeartMate II left ventricular assist device with concurrent mitral and tricuspid valve repair. Ann Cardiothorac Surg 2014;3(5):532-534. doi: 10.3978/j.issn.2225-319X.2014.08.11

