Masters of Cardiothoracic Surgery

Less-invasive tools and technique for fully magnetically levitated centrifugal pump implantation

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Clinical vignette

A sixty-year-old man with acute myocardial infarction and developing cardiogenic shock was admitted for emergency coronary angiography, revealing 30% left main stenosis, 90% left anterior descending artery (LAD) stenosis and 50% circumflex (LCX) stenosis. Successful dilatation of the LAD/LCX with drug-eluting stents (kissing stent technique) was accomplished via percutaneous coronary intervention, followed by Impella CP percutaneous assist device (Abiomed US, Danvers, Massachusetts, USA) insertion due to progressive hemodynamic instability. Severe left ventricular (LV) dysfunction with an ejection fraction of 25% persisted over the next twelve days with failure to wean the patient from Impella CP, despite combined inotropic support, including levosimendan. Given the insufficient LV recovery, contrasted with only moderate right ventricular dysfunction, and the absence of concomitant valvulopathies, the patient was scheduled for a less invasive LV assist device implantation (HeartMate 3, Abbott, Abbott Park, IL, USA). The patient was discharged twenty-one days post-implant.

Surgical techniques

Preparation

The patient is placed in the supine position and a surgical pad placed underneath the left hemithorax to spread the left-sided intercostal spaces, facilitating ventricular apex exposure. Once optimal positioning is achieved, an appropriate intercostal space to approach the apex is marked by transthoracic echocardiography. The patient is then draped using standard sterile conditions from sternum to thighs to allow bilateral groin exposure.

Exposition

Preventative measures addressing potential hemodynamic instability and expedited extracorporeal circulation should include venous cannulation guidewire insertion under transesophageal echocardiography guidance and arterial femoral access. The left anterior thoracotomy is typically from the fifth or sixth intercostal space given previous echocardiography-based visualization of the heart. The ascending aorta is exposed through an upper J-hemisternotomy, or alternatively, right-sided second intercostal space thoracotomy.

Operation

The pectoral and intercostal muscles are transected, a soft tissue retractor inserted, and the pericardial sac opened. Selective bronchial intubation with the left lung collapsed is recommended to facilitate exposure of the apex prior to commencing cardiopulmonary bypass (CPB). Both the 'first core then sew' or the opposite, 'first sew then core' techniques may be used. In the latter technique, the cuff is secured in the apical position by two Teflon-felt pledgeted polypropylene monofilament 3/0 sutures in contralateral segments and subsequently affixed by an identical non-transmural running suture without additional felt strips. Prophylactic use of surgical glue may be advisable.

The outflow graft affixed to the pump is tunneled through the pericardium, trimmed in length and sutured to the ascending aorta. After full heparinization, the side-biting clamp is removed. Arterial cannula to the ascending aorta, and the venous cannula via the femoral vein are inserted. CPB is commenced and Impella CP

retracted to the descending aorta while both carotid arteries are manually compressed to mitigate the risk of cerebral thromboembolism. Once the left ventricular (LV) apex is cored and inspected, the device is passed through the intercostal space, facilitated by a proprietary clamp (Omnimedics CZ, Ltd., Prague, Czech Republic), and the pump inflow cannula is inserted. To reduce the pump profile during insertion, the sliding lock should be kept closed during pump deployment until the pump is completely engaged into the apical cuff. Subsequently, it can be reopened and secured in the final position. Due to the limited intercostal space for pump insertion, a semi-rigid bend relief should be kept on the graft unattached to the pump body. The outflow graft is positioned parallel to the diaphragm and along the right ventricle (RV) and lateral side of the right atrium upwards to the ascending aorta. This configuration eliminates compression of the RV by the graft, as well as potential for direct damage at the time of heart transplant. Finally, the bend relief is affixed using the second dedicated proprietary clamp (Omnimedics CZ, Ltd.), providing a strong connection to the pump body. The driveline is then tunneled through the rectus abdominis muscle, externalized, and the pump is started. Upon meticulous de-airing through the outflow graft, the heart-lung machine is weaned with CPB total run-time of fifteen minutes.

Completion

Despite preserved pericardial restraint with the less-invasive implant, which optimizes physiological boundaries of right ventricular performance, our unit protocol mandates inhaled nitric oxide in the early postoperative period. Once acceptable hemodynamics and hemostasis following protamine administration are accomplished, the pump is isolated from the left lung by expanded polytetrafluoroethylene membrane, drains are inserted, and both surgical wounds are closed.

Comments

Clinical results

Initial limited single-center analyses corroborated non-inferiority of the less invasive pump implantation (1,2). Consequently, encouraging clinical outcomes were demonstrated in the multicenter, prospective, non-randomized LATERAL trial with 144 patients using the HeartWare Ventricular Assist System (HVAD) (Medtronic, Minneapolis, MN, USA) significantly outperforming the historical sternotomy access performance goal (3). A superior one-year survival outcome with the same pump was noted in emergently implanted INTERMACS 1 profile patients compared to sternotomy by Wert *et al.* (4). A paucity of published evidence exists on the newest centrifugal pump HeartMate 3, yet current unpublished institutional experience is positive, as less invasive implant strategy consistently accounts for one-third of overall implants and clearly dominates reoperation cases.

Advantages

While a less invasive strategy provides potential benefits such as reduced surgical trauma and blood loss, decreased intensive care and overall length of stay, the evidence is not conclusive. Given limited pericardial cavity exposure, this specific surgical technique may also confine adhesions in prospect of subsequent transplant. A protective effect on right ventricular function by maintaining a physiological pericardial restraint is broadly discussed. Nonetheless, a need for temporary RV support has been reported for the aforementioned surgical strategy (2). Ultimately, the authors consider the most prominent advantage in previous sternotomy implants by mitigating adhesion-related injury and bleeding to heart structures (5).

Caveats

The inherent caveat to any less-invasive surgery is limited exposure and incomplete visual control of the device components (e.g., the outflow graft). Addressing any bleeding complication and anatomical injury poses a considerable challenge, thus thoughtful and highly focused surgical technique is of paramount importance. The HVAD pump may represent a surgically more appealing alternative in terms of pump and outflow graft diameter. Nonetheless, growing evidence suggests that a less invasive HeartMate 3 implant strategy is possible. Acknowledging the difficulties with the approach due to the pump profile and the minimal intercostal incision; the use of proprietary tools to facilitate the insertion (e.g., the HeartMate 3 clamp and holder Omnimedics CZ, Ltd.) appears advantageous.

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Footnote

Conflicts of Interest: Dr. Netuka reports grants, personal fees and non-financial support from Abbott Int.; grants, personal fees and non-financial support from Carmat SA; non-financial support and other from LeviticusCardio Ltd. Dr. Ivak reports consulting fees from Abbott Int. and consulting fees from CARMAT SA. The other authors have no conflicts of interest to declare.

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