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Bilateral mini-thoracotomy approach for minimally invasive implantation of HeartMate 3

Massimiliano Carrozzini | **Jonida Bejko** | **Gino Gerosa** | **Tomaso Bottio**

Cardiac Surgery Unit, Department of Cardiac, Thoracic Vascular Sciences and Public Health, University of Padova, Italy

Correspondence
Massimiliano Carrozzini, Cardiac Surgery Unit, Department of Cardiac Thoracic Vascular Sciences and Public Health, University of Padova, Via Giustiniani 2, 35100 Padova, Italy.
Email:massimiliano.carrozzini@gmail.com.

Abstract

Left ventricular assist devices (LVADs) are an established option for the treatment of end-stage heart failure. Last-generation devices are characterized by a miniaturized pump size, allowing for intra-pericardial placement. This feature enabled the introduction of less-invasive implantation techniques, which have been linked to many favorable effects. The HeartMate 3 LVAD is a continuous-flow centrifugal pump, recently introduced for clinical use. Here, we describe the minimally invasive implantation of the HeartMate 3 through a bilateral mini-thoracotomy.

KEYWORDS

HeartMate 3, implant, left ventricular assist device, minimally invasive, off-pump, surgical technique

1 | INTRODUCTION

Since their introduction, the left ventricular assist devices (LVADs) have significantly improved in pump technology and design, leading to increased reliability and performance (1). The miniaturized pump size of last-generation devices enabled the introduction of less-invasive implantation techniques (2,3). These approaches were described for the implant of the HeartWare HVAD (Medtronic, Minneapolis, MN, USA) (3,4). The HeartMate 3 LVAD (Abbott Laboratories, Chicago, IL, USA) is a new continuous-flow centrifugal magnetically levitated pump (5,6). Here, we describe the minimally invasive implantation of the HeartMate 3 through a bilateral mini-thoracotomy.

2 | SURGICAL TECHNIQUE

A thoraco-abdominal angio-CT scan is performed in all patients before LVAD implant to define the anatomy of the thoracic structures and the position of the great vessels, and to exclude significant calcification or atheromatous disease of the aorta. Candidates to off-pump implantation are those patients with a preserved right heart function, assessed by the echocardiographic parameters and right heart catheterization. Left ventricular thrombus has to be ruled out preoperatively, as well.

The surgical procedure is presented in Video 1. The patient is placed in a supine position and a pillow is used to elevate the chest at the interscapulum level, as for a sternotomy access. The right femoral vessels are isolated at the beginning of the procedure to allow for a rapid institution of cardiopulmonary-bypass (CPB), if required. During off-pump procedures, a moderate dose of inotropes (dopamine or dobutamine, and adrenaline) is administered; in case of known pulmonary hypertension, inhaled nitric oxide is also employed.

The right anterior mini-thoracotomy (RMT) is performed through a 4–5-cm incision along the second right intercostal space, close to the sternal margin. The homolateral internal thoracic artery is ligated and divided. If needed, the third rib is dislocated from the sternum to enhance exposure. The pericardium is opened and suspended, giving access to the ascending aorta. The incision of the left anterior mini-thoracotomy (LMT) is performed below the areola in men, and at the inframammary groove in women. The intercostal space corresponding to the left ventricular apex (usually the fifth or sixth space) is entered, then, after costal retraction, the pericardium is incised and suspended. At this time, the LVAD outflow graft is tunneled through the left mini-thoracotomy to the ascending aorta, underneath the pericardium, using a blunt-tip instrument. The correct position of the outflow graft is checked from both LMT and RMT: first, the graft should lie on the

diaphragm along the acute margin of the heart; then, it should turn on the right atrial appendage to reach the distal part of the superior vena cava and, thus, the ascending aorta. Once the right position is achieved, the graft is gently stretched to cut at the proper size. Using a side clamp, the vascular prosthesis is end-to-side anastomosed with the lateral aspect of the ascending aorta. The localization of the proper LVAD insertion site on the left ventricular wall is guided by trans-esophageal echocardiography. The sewing-ring is, then, secured with interrupted pledgetted 2-0 polypropylene sutures; the tails of these sutures should not be cut at this point. A circumferential continuous over-and-over suture is added. The driveline is subcutaneously tunneled from the chest to the abdominal wall with the provided tool. The cable is, first, pulled out on the left, just above the umbilical level, and then it is passed to the right side. Doing so, the out-of-chest portion of the driveline is extended, preventing a potential retrograde device infection. The driveline is rinsed with an antibiotic solution (gentamycin) along its subcutaneous course. Unfractionated heparin (5000 UI) is administered to reach an activated clotting time of 250–300 seconds. The pump is retrogradely deaired by temporary releasing the cross-clamp on the outflow graft. The currently available coring tool of HeartMate 3 does not allow for off-pump implantation; thus, we use the HeartWare HVAD tool. After completing the apical coring, the apex of the heart is kept in position by firmly holding the tails of the sewing-ring's sutures. Then, in a rapid sequence, the coring tool is removed, the outflow graft clamp is released, and the LVAD inflow inserted. The correct device position is checked, and the holder tool is fixed. If needed, a fine needle is positioned distally in the outflow graft for deairing. Finally, the pump speed is progressively increased under trans-esophageal echocardiography monitoring of the right heart function.

We applied the described technique in four cases with a mean age of 60 ± 4 years. Cardiac diagnosis was ischemic cardiomyopathy in three cases and primary dilated cardiomyopathy in one. The device strategy was bridge to transplant in two patients and bridge to candidacy in the others. Two patients were in the INTERMACS profile 1 and required a temporary mechanical support with a para-corporeal LVAD before the HeartMate 3 implant. These two cases necessitated CPB during implant. The other two patients were in the INTERMACS profiles 3 and 4 and were implanted off-pump. All the patients were extubated within the first postoperative day and have been free of adverse events during a mean time on device of 9 ± 2 months. One patient underwent heart transplant.

3 | DISCUSSION AND CONCLUSION

The growing burden of end-stage heart failure and the limited availability of donor organs, coupled with recent improvements in performance and reliability of LVADs, have progressively increased their use worldwide (1,7–9). Last-generation devices have a reduced pump size, allowing for intra-pericardial placement. This feature enabled the introduction of minimally invasive implant techniques, which were developed and described for the HeartWare HVAD (2–4).

By avoiding full sternotomy and facilitating off-pump implants, these approaches have been associated with many favorable effects: shortened mechanical ventilation time, reduced rate of right heart failure (RHF), less bleeding, faster recovery, and reduced sternal adhesions (2,3,10,11).

Here, we showed how to apply a minimally invasive approach to the implant of the HeartMate 3, through a bilateral mini-thoracotomy. The HeartMate 3 has a slightly greater profile compared to the HVAD; however, the procedure can be performed without extending the incision. The LVAD inflow insertion is the most critical surgical step. Some authors described the use of a special clamp, designed to hold the sewing ring during the pump insertion (12). Our advice is to use the sewing-ring's sutures to hold the apex in the correct position and to facilitate the introduction of the device. This simple measure enables a rapid LVAD insertion, without requiring additional tools.

One possible drawback of the described approach is the management of post-implant RHF requiring RVAD, as the pulmonary artery (PA) is often inaccessible through the RMT. When a para-corporeal RVAD is needed, two options are available for a direct PA cannulation. One is to extend the RMT through a transverse division of the sternum and the other is to perform an additional left mini-thoracotomy (2–3 cm incision) along the second intercostal space, close to the sternal margin. Recently, two percutaneous RVAD systems have been introduced for clinical use: the Impella RP (Abiomed, Danvers, MA, USA) and the Tandem Protek-Duo (LivaNova, London, UK). The first is a percutaneous micro-axial pump positioned across the tricuspid and pulmonary valves through the femoral vein. The other is a para-corporeal device with a dual lumen cannula placed via the right internal jugular vein through the tricuspid and pulmonary valves. Early experience showed the viability of these devices, with a relatively low rate of device-related adverse events (13,14). These percutaneuous devices could be particularly useful when the described technique is applied, as they preserve the advantages of the sternal-sparing approach.

In conclusion, here we presented the feasibility of the bilateral mini-thoracotomy approach for the HeartMate 3 implant. At our institution, this became the preferred technique for isolated LVAD implants in non-reoperative cases.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

AUTHOR CONTRIBUTIONS

Concept/design; data collection; data analysis; data interpretation; drafting article; critical revision of article; approval of article: Carrozzini
Data collection; critical revision of article; approval of article: Bejko
Critical revision of article; approval of article: Gerosa
Concept/design; critical revision of article; approval of article: Bottio.

ORCID

Massimiliano Carrozzini https://orcid.org/0000-0001-5506-0201
Jonida Bejko https://orcid.org/0000-0001-5015-4823

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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