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SURGICAL TECHNIQUE

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Left ventricle reconstruction and heartmate3 implantation. The "double patch technique"

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Abstract

Background: HeartMate 3 is a left ventricular assist device, composed of a centrifugal pump. It can be applied as a myocardial recovery, a bridge to transplant, or a destination therapy, in the treatment of patients with left ventricular heart failure.

Methods: Herein we describe a technique applied against a giant aneurysmal dilatation, which combines a surgical device implantation and a left ventricular reconstruction using a double patch. Results: The patch minimizes thrombotic risk thanks to its internal bovine pericardium layer, which is in contact with blood.

Conclusions: The outlined technique is relatively reproducible and safe in a selected group of patients, as it employs a high-quality device and enables the restoration of an appropriate ventricular geometry.

KEYWORDS

cardiovascular pathology, cardiovascular research, giant ventricular aneurysm

1 | INTRODUCTION

End-stage heart failure is an arduous issue in cardiac surgery and is associated with a high mortality rate if only medically treated.[1] Heart transplantation remains the gold standard treatment, but due to limited donors, the implantation of a left ventricular assist device (LVAD) becomes the best hope for patients. Nevertheless, the application of LVAD to patients with heart failure and left ventricle (LV) aneurysm may be challenging and should be limited to selected cases. Surgical problems such as fragility of tissues, increased thrombogenic risk, and thoracic anatomy, are potential risks that may arise. The technique used in our center involves the excision of the aneurysmal tissue, the reconstruction of the left ventricular chamber by using two specific patches, and the placement of the device through the newly created cardiac apex.

2 | PREOPERATIVE EVALUATION

We limit the possibility of implanting LVAD only to patients with preserved right heart function and possible intraventricular thrombi. The presence of these conditions is assessed by and echocardiogram and right heart catheterization.

A preoperative evaluation also involves a thoracoabdominal angio-computed tomography (CT) scan. It excludes possible extensive LV and aorta calcifications, which would contraindicate the device system implantation. Additionally, we use the exam to assess the great vessels position and to establish the relationship between the aneurysm and the thoracic cavity.

CT scan and 3D trans-esophageal echocardiography (TEE) are also used in case of complex LV apical anatomy to define our operative strategy.

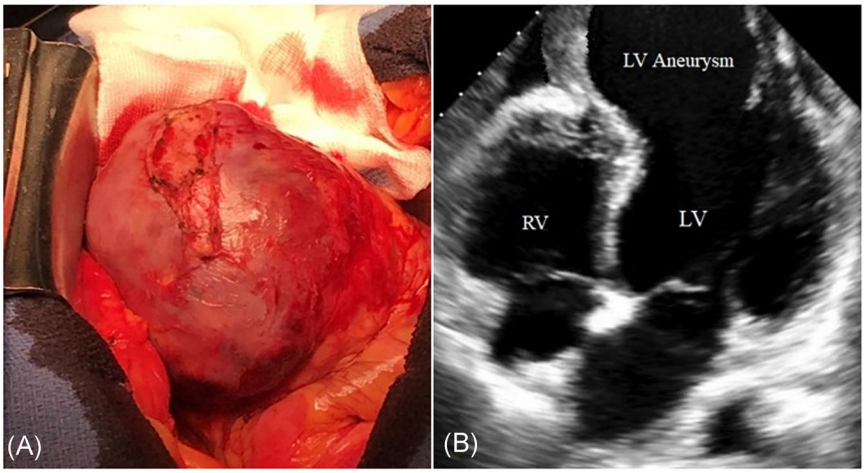

FIGURE 1 The left ventricular aneurysm. A, Direct vision on the surgical field; B, Preoperative echocardiographic control of the aneurysm. LV, left ventricle; RV, right ventricle

Figure 1B shows the preoperative echocardiographic evaluation of the left-ventricular aneurysm.

3 | OPERATIVE TECHNIQUE

In our center, every LVAD implantation is performed applying a left-thoracotomic approach through the 4th/5th intercostal space and a right-minithoracotomic approach through the 2nd intercostal space.

Nevertheless, in case of LV aneurysm, we consider the median longitudinal sternotomy the most effective and safe approach to use, because it allows a better exposure and control of the aneurysm and facilitates its subsequent reconstruction (Figures 1A and 2).

After systemic heparinization, the cardio-pulmonary by-pass is started according to the standard central or femoral cannulation technique. The aorta is then clamped and antegrade cardioplegia is administered through the aortic root.

The LV aneurysm is opened parallel to the left anterior descending artery, the ventricular cavity is inspected, and thrombotic material is eventually removed (Figure 2B). The aneurysmal fibrous scar tissue is excised until we achieve an undamaged myocardium, which is resistant enough to withstand the strain of the sutures. The new LV cavity is created using a composite patch of bovine pericardium and a dacron patch sutured together. We make the composite patch coring by using the specific tool given by Abbott. The double patch is then sutured on the LV wall with a polypropylene 3-0 running suture, placing the pericardial face directly inside the LV and the Dacron face outside (Figure 2C).

3.1 | Device implantation

The HM3 sewing ring is fixed to the double patch by interrupted sutures with pledgets (Figure 3A).

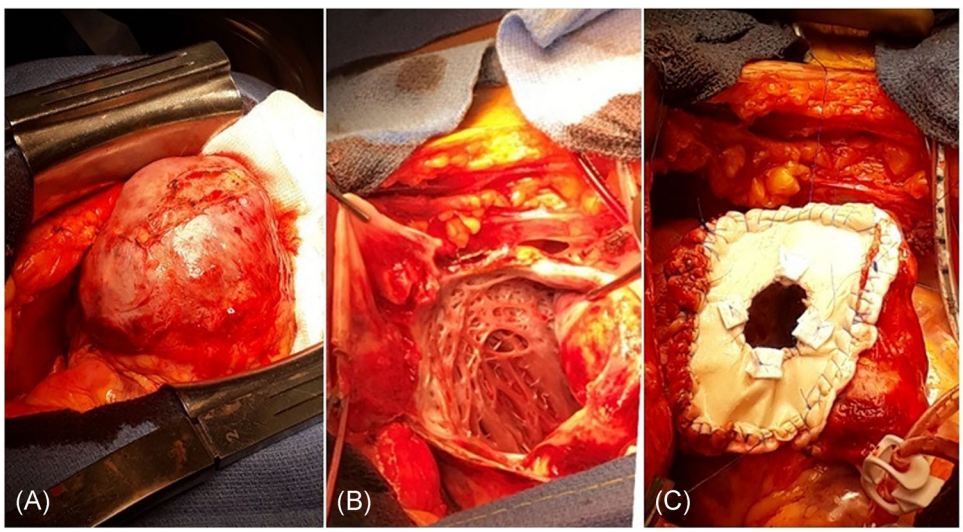

FIGURE 2 Direct vision of the left ventricular aneurysm. A, LV aneurysm; B, Opening of the aneurysm; C, Double patch implantation. LV, left ventricle

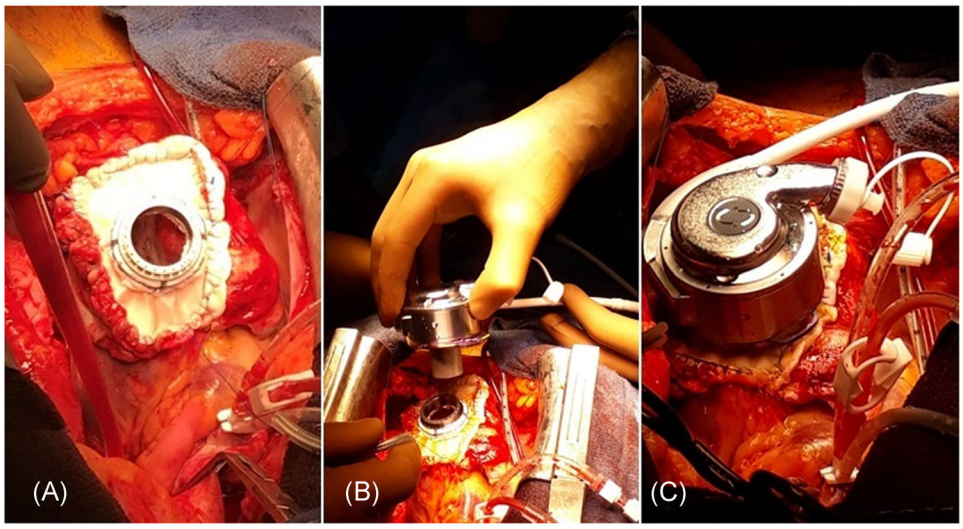

FIGURE 3 Device implantation. A, HM3 sewing ring is fixed to the double patch; B, Device implantation. C, HM 3 already implanted. HM3, HeartMate 3

The choice of the ring size depends on the patch dimension. The ring should be fully enclosed into the patch, allowing the surgeon to respect the ventricular geometry while applying the suture. This is because the ring suture should not be too close to the stitch between patch and myocardium.

The inflow conduit is then inserted into the left ventricle through the patch, with the inflow cannula directed towards the mitral valve and away from the interventricular septum (Figure 3B). The pump is then secured by a slide locking mechanism (Figure 3C). The LV and the pump are now de-aired through the outflow graft and the pump is placed in the natural pericardial pocket that previously contained the apical aneurysm. Using the tunneling device, the driveline is tunneled to its exit site in the abdomen. After carefully deairing the LV, TEE control is performed to evaluate residual bubbles and assess the correct intraventricular device position. At this time, the LVAD is started at low speed, allowing blood to fill the outflow cannula. The aortic cross clamp is now removed; the aorta is longitudinally partially clamped, opened, and end-to-side anastomized with the outflow graft (Figure 4A,B). The conclusion of the procedure is performed in standard fashion.

4 | PERIOPERATIVE COMMENTS

End-stage heart failure associated with left ventricular aneurysm is a delicate cardiac surgery problem. If heart transplantation is not possible, the only option is LVAD implantation. This procedure also presents a certain degree of concern, as the particular LV anatomy complicates the implantation and there are substantial perioperative risks.

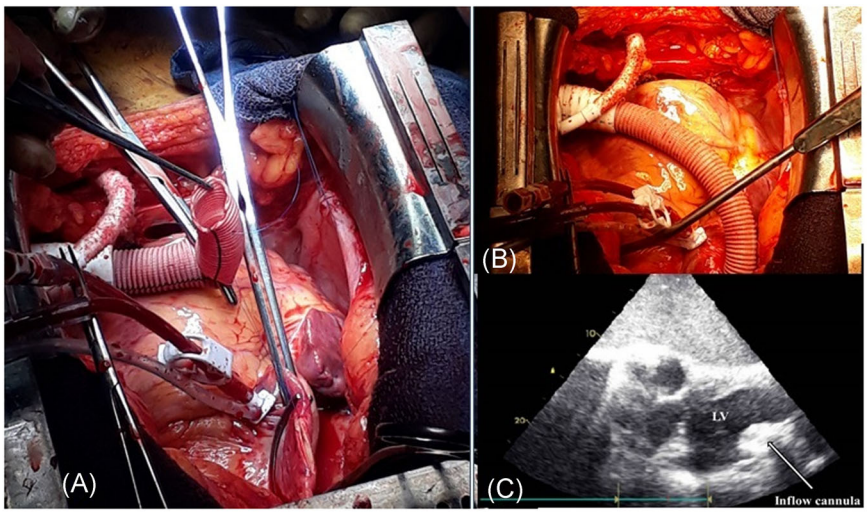

FIGURE 4 Final result. A, The outflow graft is anastomosed to the aorta; B, Conclusion of the procedure. C, Postoperative echocardiographic control

An aneurysm structure analysis is required before performing this technique. Quality of wall, presence of calcification, its extent, position of the aneurysm, and its relationship with surrounding structures should be carefully assessed.

In the literature, interesting cases of left ventricular reconstruction associated with LVAD implantation have been reported.[2-4] Bejko et al[5] described a series of four patients with challenging apex anatomy, who underwent Jarvik 2000 implantation after LV geometry had been re-established by Dor procedure. On the other hand, Chernyavskiy[6] decided to reconstruct the wall of the LV by using synthetic patch placement followed by an INCOR implantation. Lastly, Ghodsizad et al[7] have used an animal experimentation to show how an LVAD can easily be implanted using a minimally invasive and off-pump technique.

We have chosen HeartMate 3 because of its excellent hemocompatibility and its relatively small size, which allows it to be placed into the pericardial cavity and replace the aneurysmatic tissue.

In this context, we should highlight the problem of thrombogenic risk generated by the likely formation of clots on the aneurysmatic ventricular tissue.

Although the placement of a patch itself can be thrombogenic, performing a reconstruction of the left ventricle without patch implantation, can lead to an excessive reduction of the ventricular chamber, causing possible septum suction events. None of these were reported in our experience.

We believe the most challenging task is finding the right balance between the thrombogenic risk and the maintenance of a correct ventricular geometry.

We created a suitable ventricular chamber for facilitating the installation of the pump on a resistant support, interrupting the ventricular dilatation, and reducing both the amount of nonfunctional tissue and the thrombogenic intraventricular risk.

It is important to underline that in our center, all LVAD patients with patch reconstruction, as any other LVAD patient, have undergone an anticoagualtion therapy with antivitamin K antagonists (AVK), maintaining an INR ranging from 2 to 3.

We established a "double patch" technique. While the use of one internal pericardial patch reduces the risk of thrombosis thanks to its hemocompatible surface, the external Dacron patch reinforces the apex and stabilizes the positioning of the inflow cannula in the correct direction, avoiding mobilization and malposition (Figure 4C). For these reasons, we believe that our technique is relatively safe and can be reproducible in a selected group of patients, with prior preoperative evaluation of aneurysm and careful planning.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

AP: conceptualization, writing. GK: conceptualization, writing. MP: data collection. AM: data collection. WA: images collection. JP: data collection. TB: critical revision of article, approval of article, supervisor. GG: critical revision of article, approval of article, supervision. LL: critical revision of article, approval of article, supervision. LB: project administration, review and editing, supervision.

ETHIC STATEMENT

It is declared that every reasonable effort was made to obtain informed consent to participate in this study. However it is noted that there is already mention of the use of data for scientific and research purposes in the current informed consent in use at our Center. We also guaranteed the respect of anonymity and professional secrecy and used the collected data just for the scientific purposes granted in accordance with the law in force (GDPR).

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