Hybrid closure of ventricular septal defect and implantation of systemic right ventricular assist device

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Abstract

A 50-year-old female patient was readmitted with refractory systemic right ventricular failure. The patient underwent a Mustard procedure during childhood for transposition of the great arteries. A significant residual ventricular septal defect was present, which represents a major risk factor of death following ventricular assist device. We describe the combination of ventricular assist device implantation preceded by hybrid closure of ventricular septal defect.

Keywords Systemic right ventricle; Mechanical circulatory support; Hybrid intracardiac shunt closure

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Introduction

The use of ventricular assist device (VAD) for failure of systemic right ventricle (SRV) in congenital adult patients is increasing.1 Ventricular septal defect (VSD) is a contraindication to left VAD implantation. We herein describe the combination of VSD closure and VAD implantation.

Case report

A female patient underwent a Mustard procedure at the age of 3 years old for transposition of the great arteries. A small muscular VSD was left opened. Episodes of acute SRV failure, some related to atrial flutter, prompted atrial flutter ablation and implantable cardioverter-defibrillator insertion. The patient was listed for heart transplantation at the age of 40, but no graft was available for 10 years due to the presence of multiple human leukocyte antigen (HLA) antibodies (Classes I and II). During this period, she was repeatedly admitted for episodes of acute SRV failure. The patient, aged 50 years old, was readmitted in July 2020 with refractory heart failure. Pre-operative and post-operative echocardiographic data are detailed in Table 1. Extracorporeal membrane oxygenation was not considered because of the risk of weaning failure in the absence of a rapidly available graft given the patient’s HLA antibodies status. Therefore, VAD implantation was offered as a bridge to transplantation in an emergent setting. However, pre-operative bubble contrast transthoracic echocardiography was positive, and a 7 mm muscular VSD was found. VSD closure was deemed to be complex percutaneously and surgically given its location. Therefore, hybrid closure of the VSD was planned before VAD implantation to avoid post-operative cyanosis due to the reinjection in the aorta of deoxygenated blood from the subpulmonary left ventricle.

The procedure was performed in a hybrid operating room and started with transoesophageal echocardiography. No atrial shunt was demonstrated, and it was noted that drainage of the thrombosed superior vena cava was made through the aygos vein into the inferior vena cava (Figure 1A). Conventional redo full sternotomy was performed. The best location on the right ventricular wall to access the VSD was located with the conjunction of transoesophageal echocardiography and the surgeon’s finger. After installing a purse string, an 8-Fr short sheath was inserted through the right ventricular wall and the VSD (Figure 1B). A 10 mm Amplatzer...
Muscular VSD Occluder (Abbott, St Paul, MN) was inserted under both echocardiographic and scopic guidance (Figure 1C and Supporting Information, Video S1).

The left femoral vein and the ascending aorta were cannulated, and cardiopulmonary bypass was instituted during 106 min. A HeartMate 3 VAD (Abbott, St Paul, MN) was uneventfully implanted between the apex of the SRV and the ascending aorta without aortic cross-clamping (Figure 2A). The patient was extubated on the same day, and inotropic support was weaned on post-operative day (POD) 4. Discharge from intensive care unit and from hospital occurred at POD 7 and 20, respectively. There was no residual VSD and no post-operative signs of heart failure. The patient has not been readmitted for concerns with the VAD or the VSD closure.

The patient was readmitted 11 months later for heart transplantation, after desensitization with plasmapheresis, which allowed for a significant decrease of HLA antibody levels, especially Class I. The procedure was uneventful (Figure 2B), and there was no unacceptable HLAs. Immunosuppressive therapy was not increased, but tacrolimus was initiated earlier than usual (POD 1) given the high risk of rejection in our patient. However, the early post-operative course following transplantation was complicated with two consecutive episodes of septic shock from an unknown source. Extracorporeal membrane oxygenation support from POD 2 to POD 12 was required for the first episode of septic shock, but it was agreed within the team not to reinstitute mechanical support for the second episode, which caused the death of the patient at POD 22.

### Table 1 Pre-operative and post-operative echocardiographic data

|                          | Pre-operative (D – 18) | Post-operative (D + 17) |
|--------------------------|------------------------|-------------------------|
| **Systemic right ventricle** |                        |                         |
| End-diastolic diameter   | 94 mm                  | 40 mm                   |
| End-diastolic volume     | 212 mL (123 mL/m²)     | NA                      |
| Ejection fraction        | 15%                    | NA                      |
| TAPSE                    | 5 mm                   | 7 mm                    |
| Tricuspid regurgitation  | Severe                 | Mild                    |
| PISA                     | 7 mm                   | NA                      |
| Regurgitant orifice area | 30 mm²                 | NA                      |
| Regurgitant fraction     | 57%                    | NA                      |
| **Subpulmonary left ventricle** |                      |                         |
| End-diastolic diameter   | 83 mm                  | 55 mm                   |
| End-diastolic volume     | 126 mL (73 mL/m²)      | NA                      |
| Ejection fraction        | 43%                    | ‘Normal’                |
| Estimated systolic pulmonary artery pressure (left ventricle–right atrial gradient) | 47 mmHg | 24 mmHg |
| Ventricular septal defect | 7 mm                   | No residual shunt       |

D, post-operative day; NA, not available; PISA, proximal isovelocity surface area; TAPSE, tricuspid annular plane systolic excursion.

### Discussion

Various VAD have been implanted for failing SRV. The design of the HeartMate 3 inflow pump allows for its easy implantation in the apex of the right ventricle. White et al. have described the implantation of HeartMate 3 in a similar patient through a minimally invasive approach, although a left thoracotomy was added to upper ministernotomy for the inflow cannula insertion.² Mediastinal adhesions were easily dissected via full sternotomy, and no additional incision was necessary in our patient.
Our major concern for the patient was the risk of post-operative cyanosis due to the persistence of an intracardiac shunt. It has been demonstrated that the presence of patent foramen ovale following systemic VAD implantation represents a potentially lethal issue.\textsuperscript{3,4} VAD implantation has been described in the presence of post-infarction VSD\textsuperscript{5} and also with unfavourable outcome.\textsuperscript{6}

This case is, to our knowledge, the first in which hybrid closure of an intracardiac shunt and VAD implantation have been combined. Perventricular device closure of VSD is performed when access to the VSD is challenging, either surgically or percutaneously. Due to a predicted tortuous guidewire pathway between the Mustard baffle and the VSD, a percutaneous approach would have been complex, if not impossible. In addition, a surgical closure would have required aortic cross-clamping.

**Conflict of interest**

All authors declare that they have no conflict of interest.

**Supporting information**

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

**Video S1.** Hybrid closure of ventricular septal defect.

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