Proposal for bail-out procedures - Assisted circulation

A novel use of the implantable ventricular assist device for isolated right heart failure

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Abstract

Isolated right heart failure after cardiac surgery is uncommon and the prognosis remains poor. Additionally, managements for these patients are difficult. Profound postcardiotomy right heart failure developed in a 45-year-old woman after aortic root replacement for critical aortic stenosis with small aortic root. Although maximum medical therapy, intraaortic balloon counterpulsation and extracorporeal membrane oxygenator were attempted, severe right heart failure remained. Finally, an implantable right ventricular assist device (RVAD) was utilized because an immediate myocardial recovery was unlikely. The patient was discharged from the hospital at 17 days after the RVAD implantation. After 79 days of support, right ventricular function had recovered, the fully rehabilitated patient was successfully weaned from the RVAD, and the RVAD was explanted. The patient has no recurrence of heart failure 668 days after RVAD explantation.

Keywords: Heart-assist device; Right-sided heart failure; Remodeling

1. Introduction

Isolated right ventricular failure (RHF) after cardiomyoplasty is extremely uncommon. Although pharmacologic therapy, intraaortic balloon counterpulsation (IABP) and a ventricular assist device can be applied to these patients, the prognosis remains poor [1]. There were few successful reports of patients weaned from isolated right ventricular assist device (RVAD) support for postcardiotomy RHF [2], and they suggested the difficulty of their therapeutic managements [1, 2]. The use of implantable RVAD support for the postcardiotomy RHF patients, who were discharged to home to await for right ventricular (RV) recovery, has not been reported, to the best of our knowledge. We describe a patient with isolated RHF after aortic root replacement who required implantable RVAD support as a bridge to recovery. We also suggest a method for determining the indication and timing of device explantation.

2. Case report

A 45-year-old female presented with syncope and chest pain. Severe aortic stenosis was diagnosed with a mean gradient of 100 mmHg and 0.4 cm² aortic valve area (indexed 0.25 cm²/m², BSA 1.78). Echocardiograms demonstrated that there was severe left ventricular hypertrophy with diastolic dysfunction but overall normal global systolic function, and the RV function was normal. The patient was scheduled for aortic valve replacement. Standard cardiopulmonary bypass (CPB) was established with 30 °C of body temperature. Myocardial protection was achieved with retrograde cold blood cardioplegia and the cardioplegic solution was given every 15 min throughout the case for a full dose (5300 ml). Total aortic cross-clamping time was 212 min. Aortic root replacement was performed using a 21 mm porcine aortic root xenograft (Toronto SPV®, St Jude Medical Inc., St Paul, MN) due to small aortic root. After the procedure, CPB was not able to be weaned off due to RHF caused by prolonged cardiac ischemia, despite of maximum pharmacological support plus nitric oxide and an IABP. The patient required a venoarterial extracorporeal membrane oxygenator (ECMO) support at 4 l/min flow. After 24 h of support, she was weaned from ECMO, and remained quite stable with an open chest for the next five days. Attempts to close the chest were unsuccessful due to RV decompensation associated with sternal closure. RV ejection fraction (RVEF) was 22% (Fig. 1). Finally, an implantable RVAD (Thoratec IVAD, Thoratec Corp., Pleasanton, CA) was implanted with CPB and the chest was closed on postoperative day 6.

RVAD flow of 3.5 to 4.5 l/min in the fixed mode (rate 54 bpm) provided adequate circulatory support, and the patient was weaned from the respirator four days after RVAD insertion. Once extubated, rehabilitation and advancing the diet to provide adequate nutrition were worked on. In the following days, she was progressively mobilized on RVAD support. RV systolic function remained severely reduced during her hospitalization. After 17 days of RVAD
implantation, she was discharged home to wait for myocardial recovery. If myocardial recovery did not ensue, heart transplant evaluation would have occurred. After 56 days, echocardiogram showed a significant improvement of RV function (RVEF: 51%, Fig. 1). Thus, the evaluation of RVAD turnoff study was planned. After 75 days, her device alarmed and an echocardiogram and chest computed tomography revealed thrombus attached to the right atrial inflow cannula (Fig. 2), although her INR was in the therapeutic range (2.5 to 3.5). Therefore, she was admitted and heparinized. She urgently underwent an RVAD turnoff study [3], during which the device was turned off and, after full heparinization, she successfully completed a 6-min walk with RVAD hand pumping four times per minute. She passed the RVAD turnoff study very well. After 79 days of support, the RVAD was explanted without the use of CPB. Simultaneously, thrombus in the right atrium was completely removed during inflow occlusion. Further recovery was uneventful and the patient was discharged four days after RVAD explantation. She remains quite active with good exercise tolerance and there has been no recurrence of heart failure 668 days after RVAD explantation.

3. Discussion

Patients with isolated RHF following routine cardiac surgery are rare and have a poor prognosis. Moazami et al. [1] reported the incidence of isolated postcardiomyectomy RHF was 0.3% reviewing 9000 cardiac surgery cases and the mortality rate was approximately 70%, and suggested the difficulty of management of patients in RHF after cardiotomy. In our case, ECMO was necessary for weaning from CPB, in addition to the administration of nitric oxide and an IABP. After weaning from ECMO, the patient was not able to tolerate chest closure due to profound RV decompensation. Therefore, a mechanical ventricular assist device was indicated. A centrifugal pump for short-term support or a wearable VAD, either pneumatic or electric devices, as an RV assist, would have been therapeutic options. Moazami et al. [1] reported that only 13 of 30 patients with RV assist for isolated RHF after cardiomyectomy and a median duration of support of five days were successfully weaned. Joyce et al. [4] reported that the hospital mortality was 75.6% in 168 patients with centrifugal RV assist for postcardiomyectomy cardiogenic shock. All of these cases received short-term centrifugal pump support. According to the recent multicenter clinical trial with Thoratec IVAD reported by Slaughter et al. [5], the IVAD has reduced complication rates relative to the Thoratec paracorporeal VAD. In the present case, a Thoratec IVAD was chosen because an immediate myocardial recovery after cardiomyectomy was unlikely and the acute mortality rate of isolated RHF patients was reported to be high. Thus the need for a longer duration of mechanical support was anticipated and a device on which the patient could be discharged home to await RV recovery was chosen. In addition, this patient was exposed to an open chest for six days prior to RVAD implant and was considered to have a high risk for infection. During the RVAD support, no major infection occurred.

Postcardiomyectomy RHF can be caused by prolonged cardiogenic arrest, inadequate myocardial protection [6] and right coronary occlusion due to coronary vasospasm, air embolization and thrombus. RV functional preservation using cardioplegia, especially retrograde administration, is controversial. Kulshrestha and colleagues [7] reported that the use of retrograde cardioplegia provides an excellent preservation of RV function even among patients with a hypertrophied RV and pulmonary hypertension. On the other hand, Allen and colleagues [8] demonstrated that retrograde cardioplegia did not adequately perfuse the RV myocardium, due to the cardiac venous anatomy. In this case, cardioplegia was infused only retrogradely for myocardial protection, without a combination of antegrade. This inadequate myocardial protection might have precipitated RV failure after the operation.

In conclusion, we have described a patient with postcardiomyectomy isolated RHF who was successfully bridged to recovery with an implantable RVAD on which the patient was able to be discharged home to await for RV recovery, shortening the postoperative hospital length of stay. A possible method for assessment of myocardial recovery
adequate to allow VAD explantation is also briefly described. Our experience indicates that implantable RVAD therapy with devices allowing more prolonged RV support at home is one of the novel therapeutic options for postcardiotomy RHF.

References


