Alternative right ventricular assist device implantation technique for patients with perioperative right ventricular failure

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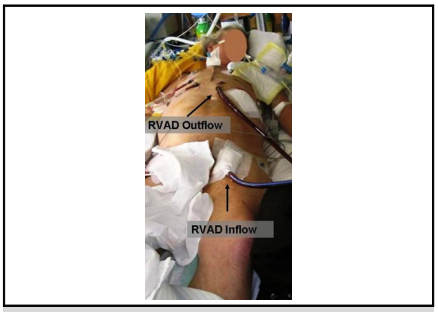
ABSTRACT

Objectives: Temporary right ventricular assist devices (RVADs) may be required to support patients with perioperative refractory right ventricular failure (RVF). We report on our experience using a different technique of RVAD implantation that does not necessitate resternotomy at the time of RVAD removal.

Methods: Patients with perioperative RVF who underwent temporary RVAD implantation between January 2010 and February 2014 were reviewed. A dacron graft was attached to the pulmonary artery and passed through a subxiphoid exit, where the RVAD outflow cannula was inserted. The inflow cannula was percutaneously cannulated in the femoral vein, and the sternum was primarily closed. On the day of RVAD explantation, the outflow graft of the RVAD was pulled and ligated, and the insertion site was secondarily closed. The RVAD inflow cannula was removed, and direct pressure was applied.

Results: Twenty-one patients (age 58 ± 14 years) were supported. Seventeen patients (81%) had RVF after left ventricular assist device implantation, and 4 patients developed postcardiotomy RVF. The median duration of RVAD support was 9 days (range: 2-88 days). Eleven patients (52%) were successfully weaned from the RVAD. Two patients were bridged to transplantation. Eight patients died on left ventricular assist device and/or RVAD support. The survival rates to discharge or heart transplantation, and to 1-year, were 62% and 52%, respectively.

Conclusions: No technical issues were encountered in this large series of RVAD implantations using the described technique for various forms of postoperative RVF. Extended support duration and reduction of resternotomy risks may be the main advantages of this technique compared with conventional RVAD implantation methods. (J Thorac Cardiovasc Surg 2015;149:927-32)



Example of a patient with simultaneous LVAD and RVAD support.

Central Message

This study reports the feasibility of an alternative technique of RVAD implantation in patients with perioperative right ventricular failure that does not necessitate resternotomy at the time of RVAD removal. Extended support duration and reduction of resternotomy risks are the main advantages of this technique compared to conventional techniques.

Author Perspective

In patients with perioperative right ventricular failure (RVF), many surgeons implant a temporary RVAD or ECMO by using open sternotomy approach. The main drawback of these techniques is the higher incidence of bleeding and infection or the necessity for resternotomy if the sternum is closed. In this study, we are reporting our experience and the feasibility of a less invasive technique of RVAD implantation for RVF that does not necessitate resternotomy at the time of RVAD removal. Twenty-one patients were supported. Seventeen patients had RVF after LVAD implantation and 4 patients developed postcardiotomy RVF. No technical issues were encountered.

See Editorial Commentary pages 933-4.

Perioperative right ventricular failure (RVF) is a devastating clinical condition with a high mortality rate that sometimes necessitates mechanical support.[1,2] A clinically significant RVF occurs in about 0.1% of patients after cardiac surgery. The incidence is higher, reaching 2%-3%, after heart transplantation, and can reach 20%-30% after left ventricular assist device (LVAD) implantation.[3,4]

Several right ventricular assist device (RVAD) implantation techniques have been described.[5-8] In the context of postcardiotomy RVF, many surgeons tend to use extracorporeal membrane oxygenation (ECMO) and leave the sternum open for a few days until the right ventricle has fully recovered. In patients with RVF after LVAD implantation, many surgeons implant a temporary RVAD through an open sternotomy approach using direct right atrial and pulmonary artery cannulation.

The main drawback of these techniques is the higher incidence of bleeding and infection when the chest remains unclosed, and the necessity for resternotomy if the sternum is closed at the time of the primary operation. Several new approaches, designed to avoid these complications, have been

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Abbreviations and Acronyms

CPB = cardiopulmonary bypass
CT = computed tomography
ECMO = extracorporeal membrane oxygenation
LVAD = left ventricular assist device
RVAD = right ventricular assist device
RVF = right ventricular failure

described for temporary RVAD implantation. The majority of descriptions are anecdotal case reports, and the approaches have been used mainly after LVAD implantation.[8-12] In this study, we aimed to report our experience using a less-invasive technique of RVAD implantation for RVF after various cardiac surgical procedures that does not necessitate resternotomy at the time of RVAD removal.

MATERIALS AND METHODS

Patient Population

The study protocol was approved by the local research ethics board. A retrospective data review was performed from January 2010 through February 2014. Inclusion criteria included having undergone RVAD implantation performed, using the technique described in the next section, after various forms of postcardiotomy RVF. Patients with veno-arterial ECMO support for postcardiotomy RVF, subjects intended for long-term biventricular support, and those who underwent direct open cannulation of the pulmonary artery were excluded from this study. The preoperative characteristics of the patients, and postoperative outcomes, are described in Table 1.

Right Ventricular Assist Device Implantation Technique

The criteria for RVAD support after LVAD implantation at our institution include an echocardiographic finding of severe right ventricular dysfunction combined with central venous pressure >20 mm Hg, mean arterial pressure of <60 mm Hg, and a low pump index of <2.2 l/min/m^2 on a more-than-moderate dose of inotropic support (epinephrine and milrinone).

The implantation was performed in all patients using a median sternotomy approach, which was necessary for the primary operation. A QuickDraw (22-25 French) (Edwards Lifesciences, Irvine, Calif) or Bio-Medicus Multi-Stage (23-25 French) venous cannula (Medtronic, Inc, Minneapolis, Minn) was used as inflow and was inserted percutaneously into the right atrium through the right femoral vein using the Seldinger technique. An 8-mm or 10-mm dacron graft (Gelweave; Vascutek, Ltd, Inchinnan, Renfrewshire, Scotland) was anastomosed end-to-side to the main pulmonary artery with a 5/0 polypropylene running suture, using a Satinsky side clamp. The outflow graft was passed transcutanously through a separate opening on the right subcostal margin, where the outflow cannula was inserted—a Fem-Flex II (21-23 French) (Edwards Lifesciences, Irvine, Calif) or an HK 36 PB-Maquet (GmbH & Co KG, Rastatt, Germany).

The graft was tied tightly around the cannula outside the chest and secured firmly to the chest wall with multiple sutures; the chest was primarily closed in all cases. Figure 1 shows a patient with simultaneous LVAD and RVAD support. In 1 patient, RVAD implantation for RVF was necessary 1 day after LVAD implantation, which was implanted through a J-sternotomy approach. Therefore, the RVAD implantation was performed using the same J-sternotomy approach (Figure 2).

The RVAD perfusion system consisted of a centrifugal pump. A Levitronix CentriMag (Levitronix GmbH, Zurich, Switzerland) was used as an RVAD in all cases. For patients with additional hypoxia, a pressure-controlled biocompatible heparin-coated silicon-membrane oxygenator, the Hilite 7000 LT (Medos Medizintechnik AG, Stolberg, Germany) or the EO 5019 (EUROSETS s.r.l., Medolla, Italy), and a heat exchanger were used. Based on our experience with noncontinuous biventricular assist device support,[13] the RVAD flow was adjusted to be 10%-20% lower than the LVAD flow in patients with LVAD support. A left atrial catheter was inserted into the left atrium in all cases to continuously monitor left atrial pressure and prevent overdriving of the RVAD flow.

Anticoagulation with heparin was started 24 hours after the surgery, with a target-activated partial thromboplastin time of 50-60 seconds. Additionally, a daily dose of 100 mg of acetylsalicylic acid was given from the first postoperative day. Anticoagulation was withheld in patients with active bleeding. In patients with LVAD, coumadin with a target international normalized ratio of 2-3 was started after removal of the chest tubes.

Right Ventricular Assist Device Explantation Technique

Removal of the RVAD support was performed after gradual reduction of the RVAD flow to 2 L/min at 0.5-L/day increments under echocardiography guidance. Meanwhile, mild doses of inotropic and phosphodiesterase inhibitor agents were initiated. RVAD removal was considered if central venous pressure was <15 mm Hg, mean arterial pressure was >60 mm Hg, and cardiac index and/or pump index remained 2.4 L/min/m^2. The skin exit site of the graft was widely prepared and draped. Gentle traction on the graft allowed the redundant portions of the graft inside the chest to be exposed. The graft was clamped and oversewn, and multiple heavy ligators were applied. Finally, the graft was reinserted into the chest, and the skin incision was closed. Removal of the inflow femoral cannula was performed after application of a deep U-stich with manual compression of the groin insertion site.

Statistical Analysis

The statistical analysis was performed using SPSS 16.0 (SPSS, Chicago, Ill). Values of continuous data are presented as mean ± standard deviation, or as median with interquartile range when appropriate. Categoric variables are displayed as frequency distributions (n) and simple percentages (%). Survival rate was calculated with the Kaplan-Meier product-limit estimator.

RESULTS

A total of 63 LVADs were implanted during this time period. Temporary RVAD using the described technique was performed in 17 patients (27%). The right ventricular function of these patients was considered severely depressed before LVAD implantation. Meanwhile, 4 patients underwent RVAD implantation for postcardiotomy RVF and were included in this study. Table 1 shows the patients' characteristics.

The postcardiotomy RVF patients included 2 patients with RVF after aortocoronary bypass surgery; 1 patient with acute RVF after aortic root replacement; and 1 patient with acute RVF after aortic root replacement and aortocoronary bypass surgery. The right ventricular function of these patients, except for 1, was documented as normal before the primary surgery. The reason for the RVF in patients with aortic root surgery may have been kinking of the right coronary artery. Fifteen patients (71%) underwent RVAD implantation at the same time as primary surgery. The mean time between primary surgery and RVAD implantation in the remaining 6 patients was 2.7 ± 2.7 days (range, 2-8 days).