

Successful Management of Thrombosis of the Proximal Aorta after Implantation with a Biventricular Assist Device

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Abstract: Continuous-flow ventricular assist devices (CVADs) are associated with a significant complication profile that includes thrombosis of the ascending aorta and aortic valve, thromboembolism, and stroke. Despite an increasing number of reports of thromboembolic complications related to CVADs, there is little in the literature to guide their management. This report

describes successful management strategies used during two cases of thrombosis of the ascending aorta during biventricular CentriMag (Levitronix LLC, Waltham, MA) support, including using pre-existing cannulas to initiate cardiopulmonary bypass. **Keywords:** BiVAD, thrombus, cardiopulmonary bypass, OHT. JECT. 2014;46:310–313

Recent advances in mechanical support have improved therapeutic options for managing patients with acute cardiogenic shock. There is growing experience with extracorporeal continuous-flow ventricular assist devices (CVADs) such as CentriMag (Levitronix LLC, Waltham, MA) as a short-term therapy (1–5). Although most commonly used in its biventricular configuration (BiVAD), the CentriMag device can also be used in an isolated right ventricular (RVAD) and left ventricular (LVAD) configuration. Despite the versatility of the device, and its successes in rescuing patients in acute cardiogenic shock, studies report mortality rates of 30–69% at 30 days (2,6).

Such high mortality rates may be associated with the significant complication profile of VADs. In one study, five of 28 patients with the continuous-flow HeartMate II LVAD (Thoratec, Pleasanton, CA) had aortic root thrombosis (7). Another single-center study reports 37% of their CentriMag patients sustained thromboembolic complications and 25% sustained strokes (5). Other studies report an incidence of neurological deficits post-CentriMag implantation of 10–11% (1,3). Despite an increasing number of reports of thromboembolic complications related to

extracorporeal CVADs, there is little in the literature to guide their management.

We describe two patients with acute cardiogenic shock who were supported by biventricular CentriMag devices while awaiting orthotopic heart transplant (OHT) and had thromboembolic complications. This report further describes a successful management strategy of these complications.

DESCRIPTION

Patient Histories

Patient A is a 38-year-old woman with a history of OHT in 2007 secondary to nonischemic dilated cardiomyopathy (NIDC) complicated by graft failure in 2012. She was subsequently supported with a BiVAD CentriMag device as a bridge for her second OHT. She developed ventricular fibrillation while on mechanical circulatory support. Despite anticoagulation with heparin initially and then argatroban, the patient developed a thrombus at the level of the aortic root and another one in the main pulmonary artery (Figure 1).

Patient B is a 31-year-old man who had NIDC and required insertion of biventricular CentriMag as a bridge to transplant. He was initially anticoagulated with heparin and had a therapeutic partial thromboplastin time. Postoperatively he developed atrial fibrillation. A transesophageal echocardiography (TEE) was obtained and showed dense, spontaneous contrast in the ascending aorta. His aortic valve was opened intermittently (every three to five beats)

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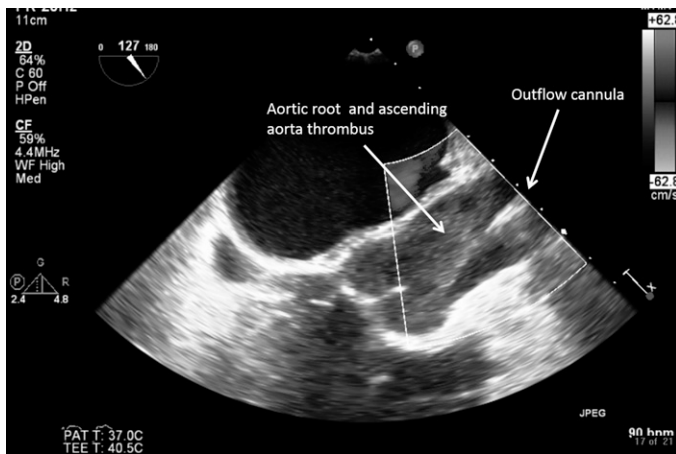


Figure 1. Thrombus in the aortic root and ascending aorta.

(Figure 2). He was switched to argatroban and within 1 week, another TEE was performed. This time, a full thrombus extending from the aortic root to the ascending aorta and around the LVAD outflow cannula was seen (Figure 2). No cardioversion was performed. Several hours before going to the operating room for OHT, the argatroban was discontinued. The intraoperative TEE showed, in addition to the aortic root and ascending aorta thrombus, extensive thrombus in the right ventricle and in the main pulmonary artery around the outflow RVAD cannula.

Continuous-Flow Ventricular Assist Device Implantation

Our center uses a similar cannulation strategy to the approach described by Takayama et al. (8) for extracorporeal BiVADs. This strategy uses a 24-Fr FemFlex (Edwards Lifesciences LLC, Irvine, CA) for the cannulation of the ascending aorta and pulmonary artery, a 40-Fr Lighthouse malleable cannula (Edwards Lifesciences LLC) for the left ventricular apex, and a 42-Fr right-angle metal tip for the right atrium. With this strategy, the aortic cannula sits deep

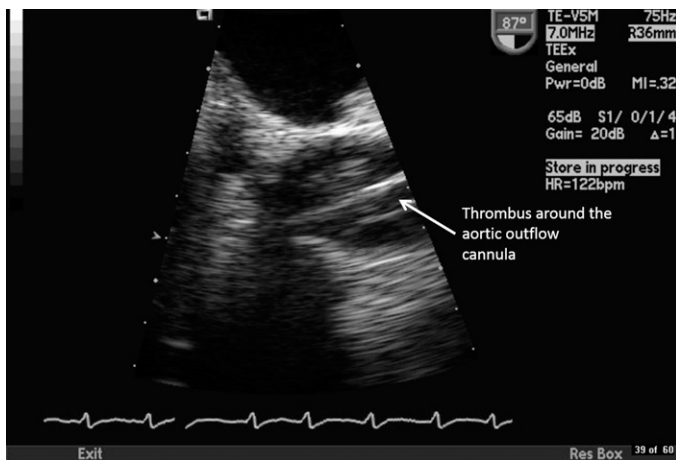


Figure 2. Thrombus around the aortic outflow cannula.

in the arch and the pulmonary artery (PA) cannula lies in the PA, just proximal to the bifurcation.

Period of Continuous-Flow Ventricular Assist Device Support

It was noted on postoperative days 7 and 10, for Patients A and B respectively, that there was a significant clot burden in the ascending aorta (Figure 1) and surrounding the aortic cannulation site (Figure 2).

A heparin-induced thrombocytopenia (HIT) panel was sent for both patients and these patients were anticoagulated with argatroban. Both HIT panels were negative. On postimplant days 17 and 14, Patients A and B, respectively, were taken to the operating room for BiVAD explant and OHT.

Continuous-Flow Ventricular Assist Device Explantation

Both patients underwent the same explantation procedure. To lessen the risk of embolism of thrombus, we used the existing cannulas to initiate cardiopulmonary bypass (CPB). Therefore, as depicted in Figure 3, without opening the chest, the existing aortic and right atrial cannulas were used as inflow and venous drainage cannulas, respectively, to initiate CPB. In addition, the left ventricular (LV) apical cannula was used as an LV vent to decrease ejection from the LV, which may lessen the risk of an embolizing thrombus distally. After conversion to CPB, the patients were cooled to 20°C.

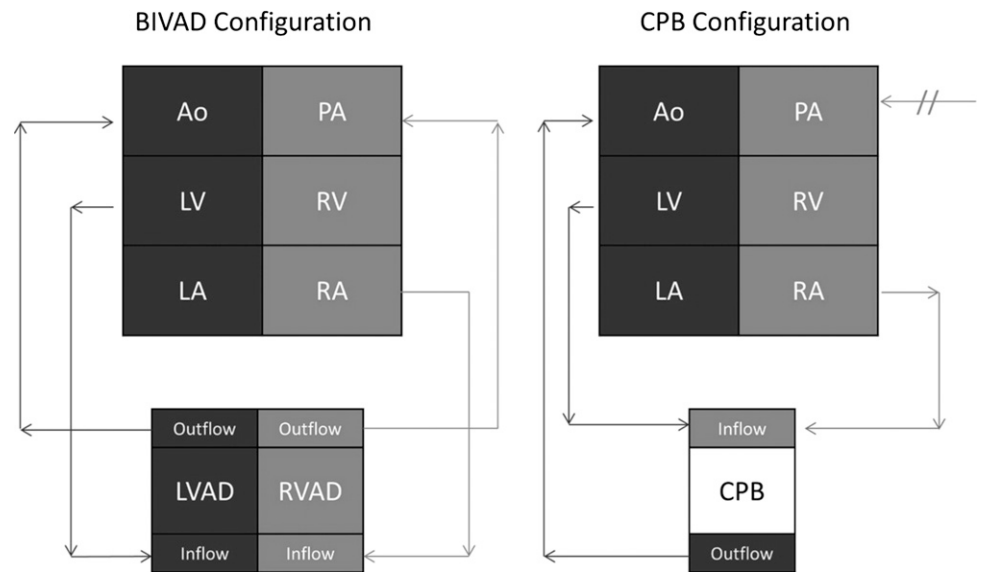
The chest was opened and the native heart was dissected free. Then, once the patient reached the target temperature, the CPB circuit was stopped, the patient was drained, and the aorta was transected. Under direct visualization, all thrombus was carefully removed from the arch and proximal aorta, and the aortic cannula was excised. These steps were repeated on the PA. Then the aorta was recannulated more distally, the aorta was deaired, and the cross-clamp was reapplied. After CPB was re-established, the patient was rewarmed, the patient was converted from single atrial venous cannulation to bicaval cannulation, and the donor heart was implanted in the standard fashion.

Both postoperative courses were uneventful. Neither patient had neurologic injury. Both patients were discharged from the hospital and continue to recover.

COMMENT

Thromboembolic complications remain the Achilles' heel of CVAD devices. Many studies have shown a high incidence of thromboembolic complications (3–5,7). It should be noted that these complications are not limited to the CentriMag device, and other investigators have hypothesized that hemolysis, blood stasis, and turbulent and retrograde flow during CVAD support contribute to thrombus formation, bleeding, and infection (9).

Figure 3. Biventricular assist device and cardiopulmonary bypass configuration.



Some groups have reported successful use of fibrinolytic therapy in the setting of thrombus-related pump failure in continuous flow VADs (10), whereas other groups have described failure of fibrinolytic therapy requiring emergency pump exchange (11). Although fibrinolytics may be effective in patients with no immediate prospect of OHT, our group describes important perioperative management strategies to minimize the burden of these complications in bridge to transplant (BTT) patients who are undergoing concomitant BiVAD explant and OHT.

Intraoperative Management

Conventionally, explanation of extracorporeal devices is performed by recannulating the aorta more distally than our approach here by releasing the snares securing the cannula and by sliding the cannula out of the aorta before cross-clamping the aorta. In patients with thrombus adherent to the cannula, however, this maneuver may force embolization of the thrombus to the brain or other organs. To prevent this potentially catastrophic complication, we attempted to limit the disruption in flow dynamics by using the existing cannulas to initiate CPB. This allowed us to remove the thrombus and existing cannulas under direct visualization during a brief period of circulatory arrest.

Anticoagulation While on Support

In the absence of particular hypercoagulable states such as HIT, the usual anticoagulation regimen for mechanical circulatory support is intravenous heparin or oral warfarin in the case of durable devices such as the Thoratec Heartmate 2. Because patients on the CentriMag will not be discharged with this device, warfarin is not appropriate. There are little data on the use of argatroban, but we believe that direct thrombin inhibition may be of value in

these thrombogenic patients with long tubing lengths, although we acknowledge that more investigation is needed (12,13).

Surveillance While on Support

Our center has since adopted aggressive use of imaging strategies for surveillance of the proximal aorta, including transthoracic echocardiography and TEE. All patients with temporary circulatory support undergo transthoracic echocardiography (TTE) on postoperative day 1. If the imaging is technically inadequate, then TEE is performed. Under echo guidance, the rotational speed of the RVAD and LVAD pumps is adjusted. To prevent LV or aortic root stasis, we monitor the position of the interventricular septum with regard to the LVAD inflow cannula as well as the frequency of the aortic valve opening and the severity of mitral regurgitation. We also attempt to allow for intermittent opening of the pulmonary valve to avoid continuous pulmonary insufficiency and the risk of main pulmonary artery stasis and/or thrombus. This is most typically accomplished by matching the LVAD and RVAD flows. By matching the flows, we avoid increasing the tricuspid valve annulus diameter, which would subsequently increase the severity of tricuspid regurgitation. In addition, TEE imaging also allows assessment of clot, especially in the left atrial appendage.

Initially, we monitor mean arterial pressure by continuous monitoring through an arterial line. Later in the postoperative period, Doppler blood pressure monitoring is used. While the ideal speed and flow settings for both the RVAD and the LVAD are being established, we monitor changes in mean arterial pressure, flow and loading conditions, afterload, and patient clinical status. Any change in hemodynamic status will trigger prompt evaluation by

imaging study (TTE initially, and if imaging is inadequate, then TEE). In addition, gated-computed tomography scans of the chest to detect clot formation before CVAD explanation may have a role in cases where clinicians have a high clinical suspicion of thrombus.

If aortic root (and/or main pulmonary artery) stasis or thrombus is noted with complete closure of the aortic valve during any portion of the cardiac cycle in a patient who is on therapeutic anticoagulation with heparin, we will change to argatroban while awaiting HIT studies. We will perform an imaging surveillance study several days (3–5 days) postargatroban to assess clot dissolution. If clot still persists, we will intensify anticoagulation and repeat imaging studies accordingly.

Pre-Emptive Measures

Modifications of device management and surgical technique should be explored in an effort to decrease the risk of thrombus formation. Changes in device management may include the modification of anticoagulation strategies (both in type of anticoagulant and in level of anticoagulation) and device parameters such as device speed and flows in an effort to promote pulsatility. Increased pulsatility would allow the heart valves to open and close, thereby decreasing blood stasis. Changes in surgical techniques include the use of shorter inflow cannulas, although this will increase the risk of dislodging the cannulas. Alternatively, a cannulation strategy involving grafts anastomosed directly to the aorta and PA, rather than cannulas, should be considered. This strategy is unlikely to eliminate clot formation in the aortic root, but it may prevent clot in the aortic arch.

In conclusion, this report describes successful management strategies used during two cases of thrombosis of the ascending aorta during biventricular CentriMag support, including using pre-existing cannulas to initiate CPB.

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