

The Aortic Valve: The Gatekeeper of the LVAD



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INTRODUCTION

The integrity of the aortic valve is of utmost importance for patients with left ventricular (LV) assist device systems, and aortic regurgitation (AR) is a common cause of morbidity in this patient population.¹ We present a case of severe cardiogenic shock and multiorgan failure in the setting of acutely worsening AR due to native aortic valve and aortic root thrombosis in a patient with an LV assist device (LVAD) system. We review diagnostic and therapeutic modalities for aortic valve thrombus in patients with LVAD systems.

CASE PRESENTATION

A 71-year-old man presented with a medical history of diabetes mellitus, prior stroke, and alcoholic cardiomyopathy, with an LV ejection fraction of 25% and a primary prevention automatic implantable cardioverter-defibrillator and severe mitral regurgitation. Six months before the present hospitalization, the patient was experiencing frequent hospitalizations for acute decompensated heart failure. He underwent biventricular pacing upgrade of his automatic implantable cardioverter-defibrillator and was managed medically with inotropes and diuretics. Over a period of weeks to months, the patient was maintained on this regimen while he underwent testing and preparation for LVAD implantation. Approximately 3 months before this presentation, a HeartMate III LVAD system (Abbott Vascular, Santa Clara, CA) was successfully implanted, and the patient underwent mitral annuloplasty repair because of the significant mitral regurgitation. During the postoperative period, the patient was discovered to have a LV outflow thrombus on cardiac computed tomography involving the aortic sinus, and his international normalized ratio (INR) goal was beyond the normal range of 2 to 3. Transthoracic echocardiography at the same time confirmed the presence of the thrombus and revealed minimal aortic insufficiency.

The patient was discharged and felt well at home and had no complications except a labile INR, causing frequent changes to his warfarin dosing. Approximately 3 weeks before presentation, warfarin was increased from 10 to 15 mg/d because of an INR of 1.6. A subsequent INR of 3.5 prompted further adjustment of warfarin dosing to 15 mg 5 days per week and 10 mg 2 days per week. Subsequent INR assessment approximately 2 weeks before admission revealed an INR of 8.6, after which the patient was instructed to hold his warfarin for 4 days before repeat laboratory analysis. Repeat INR was 1.7, and warfarin was restarted at a lower dose of 5 mg/d. Warfarin dosing

continued to be adjusted and intermittently held as the patient's INR fluctuated between 1.7 and 4.0. Notably, the patient was not found to be significantly anemic (hemoglobin 10–11 g/dL), and lactate dehydrogenase was normal (between 208 and 277 U/L) over this time period. Repeat transthoracic echocardiography over this time period revealed an improving LV outflow tract/aortic sinus thrombus and minimal AR.

Ultimately, about 2 weeks after these adjustments to his anticoagulation, the patient presented to the emergency department in severe cardiogenic shock with respiratory distress requiring intubation, multiorgan failure, and lactic acidosis. On interrogation, the patient's HeartMate III had normal power and flow indices. Laboratory analysis revealed hemoglobin of 8.8 g/dL and lactate dehydrogenase of 7,259 U/L, concerning for a hemolytic process. The patient was thrombocytopenic and coagulopathic, likely from acute hepatic injury, with an INR of 6.1, which was reversed with fresh frozen plasma and prothrombin complex concentrate. Although anticoagulation was held, INR remained in the therapeutic range.

Transthoracic echocardiography (TEE) was performed to better evaluate the aortic valve and the sinuses and revealed severe AR, significantly worse than previously seen. The left coronary cusp was thrombosed and immobilized in the open position, and the noncoronary cusp was partially immobilized by thrombus (Videos 1–4). Also, moderate to severe mitral regurgitation and moderate to severe tricuspid regurgitation were seen. LVAD inflow and outflow velocities were found to both be 2 m/sec, consistent with normal function.

The patient was initially managed supportively with diuretics, inotropes, and mechanical ventilation to reverse some of the metabolic abnormalities present. The patient was stabilized over a period of 3 days, as evidenced by improving lactic acidosis, renal function, urinary output, and hepatic function, and he was taken for aortic root thrombectomy, closure of the aortic valve, tricuspid valve repair, and LVAD outflow graft revision. The patient subsequently recovered over a 1-month hospital course that was complicated by several nosocomial infections and was ultimately discharged.

DISCUSSION

AR is a common adverse event in patients with LVADs, which can lead to cardiogenic shock due to the formation of an LV-aortic circuit and inability to perfuse the systemic circulation. AR is generally caused by long-term remodeling of the aortic cusps because of the altered hemodynamics as the LVAD interacts with the vascular system.² Aortic valve thrombus can be due to persistent closure of the aortic valve and stasis of blood in the aortic sinus. This appears to occur most often in the noncoronary cusp. There have been case reports of aortic valve thrombus causing aortic stenosis in patients with LVAD systems.¹ More rare is aortic insufficiency due to aortic valve thrombus,³ as seen in our case.

Valvular thrombosis in the setting of an LVAD is relatively rare, such that guidelines for diagnosis and treatment must be extrapolated from data regarding valvular thrombosis in absence of an LVAD system. Although in patients without LVADs, native valve thrombosis is relatively rare, mechanical prosthetic valve thrombosis is a readily seen

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VIDEO HIGHLIGHTS

Video 1: Three-dimensional view of the aortic valve via TEE. The left coronary cusp is immobile, and the noncoronary cusp is partially immobilized.

Video 2: Long-axis view of the aortic valve by TEE. Thrombus can be appreciated in the sinus of Valsalva adjacent to the noncoronary cusp.

Video 3: Short-axis view of the aortic valve by TEE. Again, the left coronary cusp is shown to be immobile, and the noncoronary cusp is partially immobile.

Video 4: Long-axis view of the aortic valve with color Doppler by TEE demonstrating severe AR.

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complication for which there are a great deal of data. If a patient presents with suspected mechanical valve thrombosis, this can be evaluated with either transthoracic echocardiography or TEE or with computed tomography.⁴ Echocardiography is beneficial to further delineate the hemodynamic effects of the thrombus and in cases such as ours, in which the hemodynamic instability of the patient necessitated that the diagnosis be made in an intensive care unit. TEE, also as seen in this case, is particularly useful to delineate the exact mechanism of valvular dysfunction.

Generally, aortic valve thrombus in the setting of an LVAD system requires surgical intervention for patient survival. If surgery is absolutely contraindicated, there have been cases of attempted treatment with anticoagulation alone, though this has been fraught with high morbidity (primarily cerebrovascular accident) and mortality. Although guidelines for thrombolysis in prosthetic valves exist, there are few data to guide the use of thrombolysis in the setting of aortic valve thrombosis in the setting of an LVAD. Nonetheless, such prosthetic valve thrombolysis protocols have been attempted in this more rare presentation involving LVADs when no other options were available.⁵

Such prosthetic valve thrombosis treatment protocols suggest to stratify patients on the basis of the severity of their presentation. If the patient is hemodynamically unstable, the patient should be empirically started on intravenous heparin, and surgical valve replacement should be performed if the patient is deemed an acceptable surgical risk. If the patient is a poor surgical candidate, intravenous fibrinolysis should be attempted. If the patient presents with decompensated heart failure symptoms but is hemodynamically stable, efficacy of anticoagulation can be assessed before deciding whether the patient would be a candidate for surgery or whether less invasive approach would be more appropriate.⁴

If fibrinolysis were to be attempted in the setting of valvular thrombosis in a patient with an LVAD system, again data from prosthetic valve thrombosis treatment must be extrapolated. In prosthetic valve thrombosis, TEE-guided systemic thrombolysis has been shown to be safe and effective, particularly using low-dose, slow or "ultraslow" infusion protocols.^{6,7}

Another potential option in patients whose surgical risk is deemed too high is transcatheter valve replacement. Although transcatheter aortic valve replacement is a widely accepted and expanding modality for treatment of aortic stenosis, its efficacy in treatment of AR is a topic

of ongoing research. Although there are no current randomized control trials comparing surgical versus transcatheter valve replacement in patients with pure AR, there are registry data demonstrating its feasibility, particularly with newer generation transcatheter valves.^{8,9} Likewise, there are no randomized control trials regarding transcatheter aortic valve replacement in patients with AR and LVADs, though this approach has been used in rare situations and has been shown to be feasible as well.¹⁰

In conclusion, there are few data to guide the optimal diagnostic study for the detection of valvular thrombosis in the setting of an LVAD and likewise few data to guide treatment. TEE has been shown to be useful for the diagnosis of prosthetic valvular thrombosis in general^{4,11} and has been used to safely guide thrombolysis of prosthetic valve thrombi,^{6,7} though these less invasive strategies have been less successful in patients with LVADs.⁵ As shown in this case report, TEE can be a valuable tool to assess the aortic sinus and aortic valve in the setting of an LVAD and should be strongly considered when such pathology is clinically suspected.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.case.2020.05.015>.

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