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CASE REPORT

WILEY Echocardiography

Aortic root thrombus complicated by left main coronary artery occlusion visualized by 3D echocardiography in a patient with continuous-flow left ventricular assist device

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Aortic root thrombus is an uncommon complication of continuous-flow left ventricular assist devices (LVAD). We present the case of a 71-year-old man with ischemic cardiomyopathy who underwent destination therapy HeartMate II LVAD placement. Eighteen months later, he presented with a cerebrovascular accident followed by myocardial infarction. Transesophageal echocardiography revealed an aortic root thrombus spanning the left and noncoronary cusps and obliterating the left main coronary artery. We discuss the incidence, risk factors, and management of aortic root thrombus in LVAD patients. To our knowledge, this is the first report of three-dimensional echocardiography used to characterize an LVAD-associated aortic root thrombus.

KEYWORDS
aortic root thrombus, coronary artery occlusion, left ventricular assist device, three-dimensional transesophageal echocardiography

1 | CASE REPORT

A 71-year-old man with an ischemic cardiomyopathy and severely reduced ejection fraction of 10% who underwent destination therapy with HeartMate II (Thoratec, Pleasanton, CA) continuous-flow left ventricular assist device (LVAD) and surgical aortic valve closure 18 months prior presented to our institution with a cerebrovascular accident followed by an acute myocardial infarction.

His medical history also included hypertension, coronary artery disease, persistent atrial fibrillation, and implantation of a biventricular cardioverter-defibrillator. One week prior to the current presentation, he had been admitted with weakness, agitation, and visual disturbances and was found to have a large right middle cerebral artery infarct involving the frontotemporoparietal territories. At that time, the patient was on aspirin 81 mg daily as well as systemic anticoagulation with warfarin with an international normalized ratio (INR) level of 2.3. Given the risks of hemorrhagic conversion in a patient with a continuous-flow LVAD following a large acute stroke, anticoagulation was withheld for one week. His neurologic examination and serial computed tomography head scans remained stable, and he was therefore restarted on warfarin therapy without bridge prior to discharge.

The patient felt well until one week after discharge when he presented with rapidly accelerating angina. On physical examination, he was diaphoretic and in mild distress due to ongoing chest pain. Mean arterial pressure was 88 mm Hg, respiratory rate 24 per minute, and oxygen saturation 98% without supplemental oxygen. Electrocardiogram revealed an atrial-sensed, ventricular-paced rhythm at 75 beats per minute and nondiagnostic for ischemia. He was euvolemic with a jugular venous pressure of 6 cm, clear lungs, and warm, well-perfused extremities without edema. Laboratory examination revealed an INR of 1.5; his first troponin was negative but subsequently rose to 50 ng/mL (normal ≤0.04 ng/mL). He had normal renal function and no leukocytosis, anemia, or thrombocytopenia.

Following transthoracic echocardiography (TTE) suggestive of aortic root thrombus (Figure 1 and movie clip S1), the patient underwent

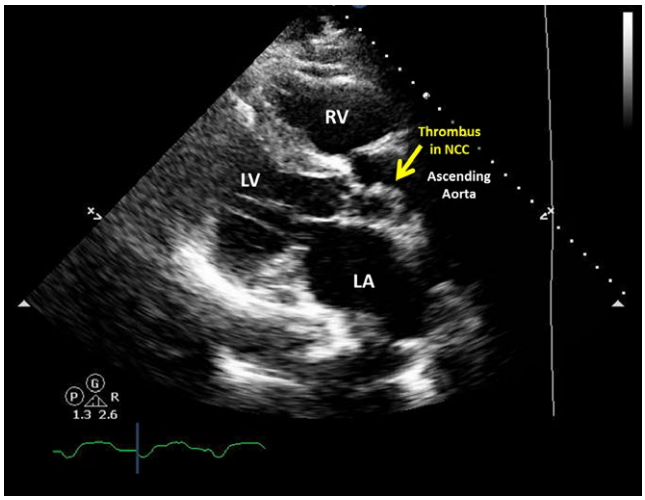

FIGURE 1 Transthoracic echocardiography demonstrates an echodensity in the noncoronary cusp (NCC) of the aortic valve (arrow) suggestive of a thrombus. Movie clip S1 corresponds to this figure. Abbreviations: LA=left atrium; LV=left ventricle; NCC=noncoronary cusp; RV=right ventricle

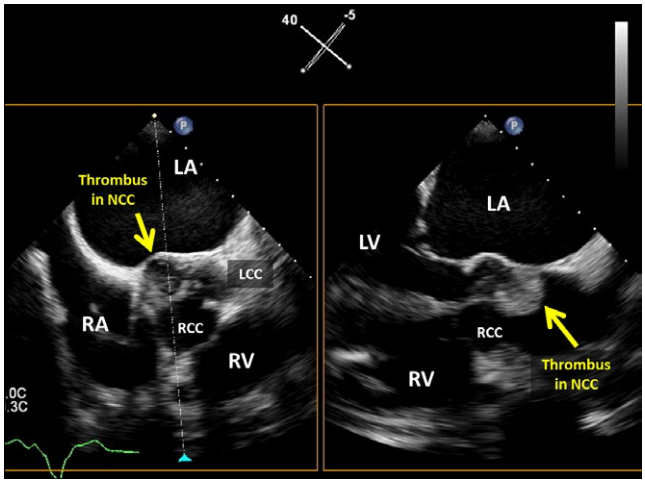

FIGURE 2 Two-dimensional transesophageal echocardiography revealed a 1.8×2.6 cm thrombus in the aortic root. Central echolucency in inner aspects of thrombus suggests clot resorption. Movie clip S2 corresponds to this figure. Abbreviations: LA=left atrium; LCC=left coronary cusp; LV=left ventricle; NCC=noncoronary cusp; RA=right atrium; RCC=right coronary cusp; RV=right ventricle

urgent transesophageal echocardiography (TEE) using the Philips Epiq ultrasound system (Andover, MA, USA) and X7-2t 3D TEE probe to evaluate for aortic root pathology which revealed a 1.8×2.6 cm thrombus in the aortic root (Figure 2 and movie clip S2). The thrombus was present in the left and noncoronary cusps and extended distally, obliterating the ostium of the left main coronary artery (LMCA). There was no flow in the LMCA on color or spectral Doppler (Figure 3 and movie clip S3). Normal continuous low velocity flow was noted in the proximal right coronary artery originating from a thrombus-free right coronary cusp (Figure 4 and movie clip S4). The aortic valve had been previously surgically closed and did not open during systole.

3DTEE provided incremental diagnostic utility in defining the extent and location of the massive thrombus in the aortic root (Figure 5, and movie clips S5 and S6) and its anatomic relations to the surrounding structures (Figure 6 and movie clip S7).

Given prohibitively high surgical risk, the patient was treated medically with intravenous heparin and bridged to warfarin. Aspirin was also continued. Clopidogrel was not started due to recent stroke and risk of hemorrhagic conversion. Repeated computed tomography of the head revealed evolving infarcts without hemorrhage, midline shift, or other acute pathology.

Subsequently, the patient developed ventricular tachycardia storm likely related to his proximate myocardial infarction, which was difficult to control but eventually suppressed with esmolol, amiodarone, lidocaine, and quinidine drips. A few days later, he developed recurrent right middle cerebral artery infarct despite a therapeutic INR level of 2.5 with residual left hemiplegia, significant cerebral edema, compression, and midline shift with concern for uncal herniation. He was treated with mannitol and hypertonic saline and remained neurologically stable without progression of edema or herniation.

Upon developing recurrent refractory ventricular tachycardia storm and ventricular fibrillation despite aggressive medical therapy, the patient underwent successful radiofrequency ablation of ventricular tachycardia (with foci in mid-inferior, inferoseptal, and septal left ventricle). He remained stable and was discharged to a subacute rehabilitation center. Unfortunately, he presented again 3 months later with aphasia and left gaze deviation due to recurrent cerebrovascular accident. Given the extent of injury and lack of further therapeutic options, he was transitioned to palliative care and expired soon thereafter.

2 | DISCUSSION

The HeartMate II continuous-flow left ventricular assist device was approved for destination therapy in 2010, and 46% of all implants are now performed for destination therapy.[1] Destination therapy LVADs significantly improve survival in end-stage heart failure patients, with survival exceeding 76% at 1 year and 57% at 3 years.[1] Although the overall rate of adverse events has decreased with newer devices and clinical experience, they continue to be common and limiting.[1] While not the most frequent complication, there have been several reports of aortic root thrombosis with continuous-flow LVADs.[2-8]

Although the event rate of aortic root thrombosis has not been defined, the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) database reports that the rate of arterial non-CNS thrombosis in the first 12 months postimplant among the 7286 patients who received continuous-flow devices from 2012 to 2014 was 0.17 events/100 patient-months.[1] One case series reported that among 318 patients who underwent HeartMate II LVAD implantation at the Texas Heart Institute, four patients developed an aortic root thrombus despite systemic anticoagulation.[2] Other single center experiences have reported higher rates with a trend toward increased mortality in these patients compared to those who do not develop aortic root thrombus.[3]

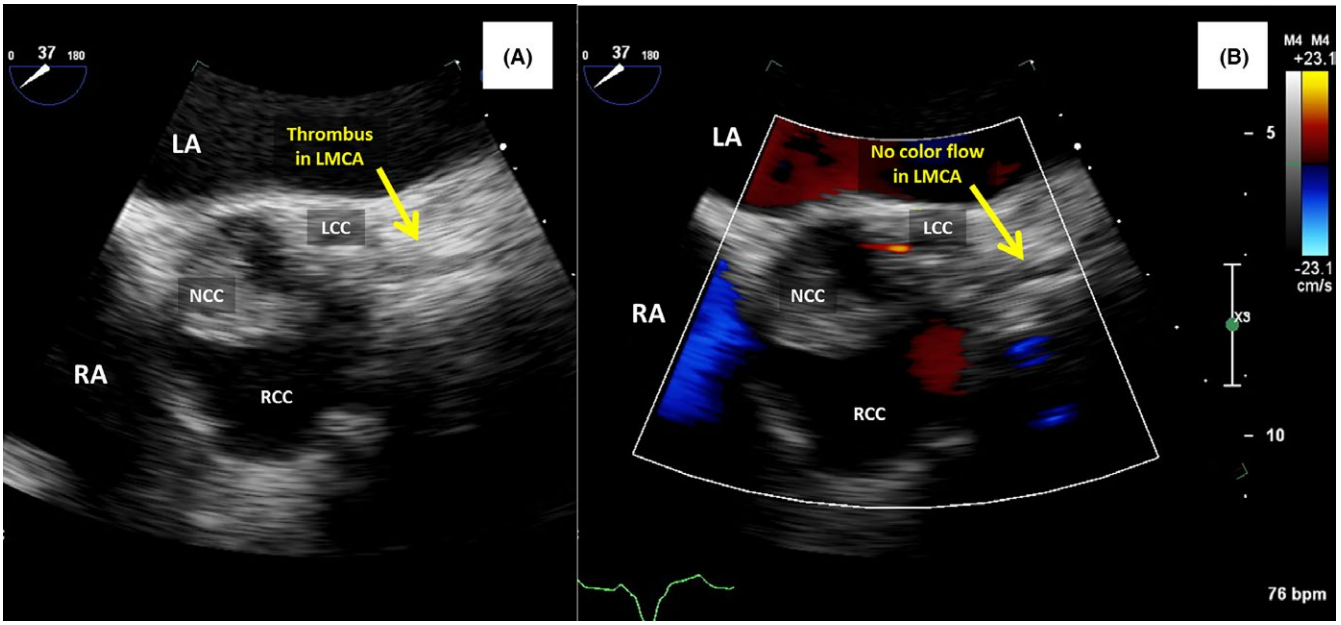

FIGURE 3 A. The thrombus spanned the left and noncoronary cusps and extended distally, obliterating the ostium of the LMCA (arrow). B. There was no flow visualized in the LMCA on color Doppler (arrow). Movie clip S3 corresponds to this figure. Abbreviations: LA=left atrium; LCC=left coronary cusp; LMCA=left main coronary artery; NCC=noncoronary cusp; RA=right atrium; RCC=right coronary cusp

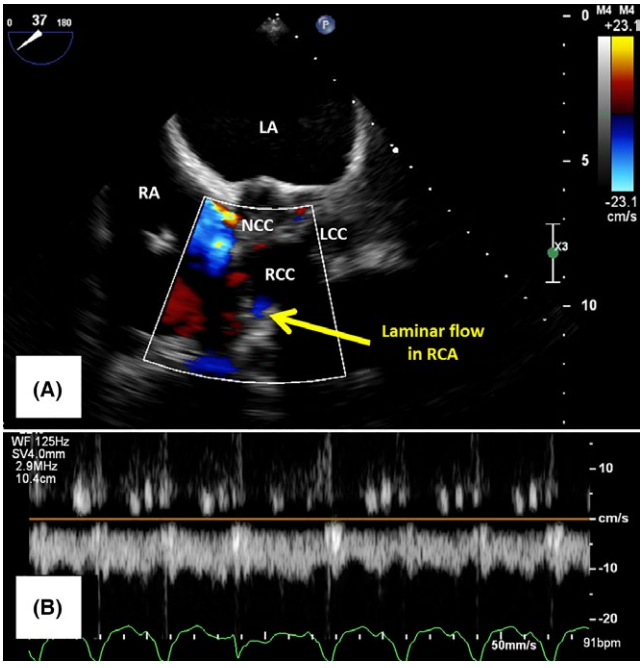

FIGURE 4 A. Laminar flow was visualized in the proximal right coronary artery (arrow) consistent with normal flow without thrombus. B. There was normal continuous low velocity flow measuring 0.12 m/s in the right coronary artery on spectral Doppler. Movie S4 corresponds to this figure. Abbreviations: LA=left atrium; LCC=left clip coronary cusp; NCC=noncoronary cusp; RA=right atrium; RCA, right coronary artery; RCC=right coronary cusp

Aortic root thrombosis should be suspected in any patient with an LVAD who presents with embolic phenomena. TEE has higher sensitivity for the detection of aortic root thrombus than TTE. TEE can also better visualize the extent of an aortic root thrombus and characterize obstruction of flow into the coronary arteries in patients with signs of acute myocardial infarction. Three-dimensional TEE can further characterize an aortic root thrombus, and to our knowledge, this is the first report of utilization of 3DTEE in an LVAD patient with aortic root thrombus.

The exact mechanism of aortic root thrombosis in LVAD patients is unclear. One may hypothesize that decompression of the left ventricle with continuous-flow LVADs often decreases blood flow across the aortic valve causing it to open less frequently. This stagnation of blood flow promotes thrombogenesis in the aortic root. Thus, patients with surgical closure of the aortic valve are likely at increased risk of aortic root thrombus. In addition, the location and angle of the outflow-graft anastomosis may also affect blood flow in the aortic root.[9]

In patients with a patent aortic valve, the risk of aortic root thrombus is likely decreased by aortic valve opening which facilitates physiologic blood flow across the aortic valve and root. Anticoagulation and antiplatelet therapy with warfarin and aspirin as per guideline recommendations [10] also lowers the risk of both arterial and pump thrombosis.

Given the recent recognition and low incidence of this complication, optimal management strategy for aortic root thrombosis has not been established, and there lacks evidence or expert recommendation on its management. In patients who are hemodynamically stable and asymptomatic or those who are not surgical candidates, the current practice is to medically manage with an intensified anticoagulant and antiplatelet regimen if bleeding risk is not prohibitive. Determination of anticoagulation strategy often involves weighing the risk of increased thrombus burden and risk of embolization against bleeding risk, as highlighted in our patient with recent stroke and risk of hemorrhagic conversion.

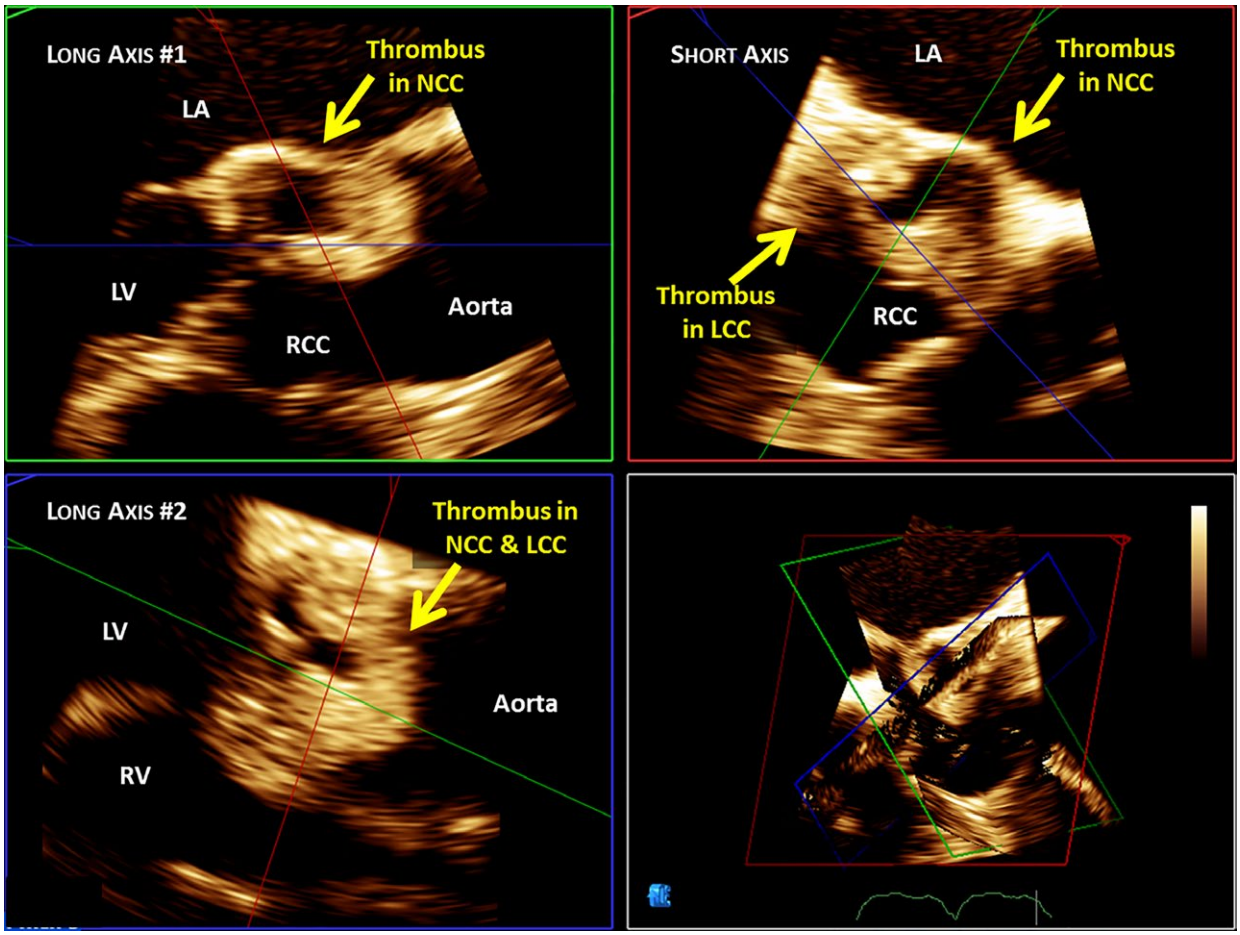

FIGURE 5 3DTEE with multiplane reconstruction at the level of the aortic root demonstrates the massive thrombus involving both the left and the noncoronary cusps of the aortic valve. Movie clips S5 and S6 correspond to this figure. Movie clip S6 demonstrates the incremental value of systematic cropping through the 3D dataset for complete evaluation of the thrombus size and location. Abbreviations: LA=left atrium; LCC=left coronary cusp; LV=left ventricle; NCC=noncoronary cusp; RCC=right coronary cusp; RV=right ventricle

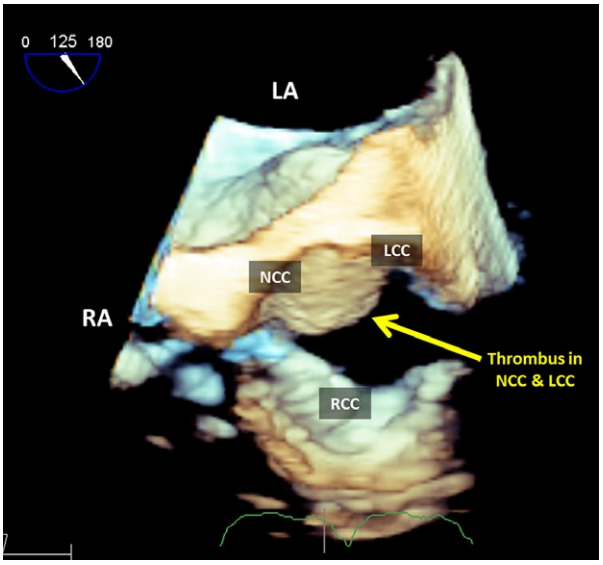

FIGURE 6 3DTEE demonstrates thrombus in the left and noncoronary cusps and its anatomic relations to the surrounding structures. Movie clip S7 corresponds to this figure. Abbreviations: LA=left atrium; LCC=left coronary cusp; NCC=noncoronary cusp; RA=right atrium; RCC=right coronary cusp

Aortic root exploration and thrombectomy has been performed in two prior cases of aortic root thrombus complicated by left main coronary artery occlusion in the early postoperative period after LVAD implantation.[4,5] Once an aortic root thrombus has developed, another consideration is to increase the LVAD speed to prevent aortic valve opening and decrease the risk of dislodgement in patients with a patent aortic valve.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

Movie clip S1. Transthoracic echocardiography demonstrates an echodensity in the noncoronary cusp (NCC) of the aortic valve (arrow) suggestive of a thrombus. Abbreviations: LA, left atrium; LV, left ventricle; NCC, noncoronary cusp; RV, right ventricle

Movie clip S2. Two-dimensional transesophageal echocardiography revealed a 1.8×2.6 cm thrombus in the aortic root (arrow). Central echolucency in inner aspects of thrombus suggests clot resorption. Abbreviations: LA, left atrium; LCC, left coronary cusp; LV, left ventricle; NCC, noncoronary cusp; RA, right atrium; RCC, right coronary cusp; RV, right ventricle

Movie clip S3. The thrombus spanned the left and noncoronary cusps and extended distally, obliterating the ostium of the LMCA. There was no flow visualized in the LMCA on color Doppler. Abbreviations: LA, left atrium; LCC, left coronary cusp; LMCA, left main coronary artery; NCC, noncoronary cusp; RA, right atrium; RCC, right coronary cusp

Movie clip S4. Color Doppler demonstrated normal laminar flow (arrow) in the proximal right coronary artery originating from a thrombus-free right coronary cusp. Abbreviations: LA, left atrium; RA, right atrium; RCC, right coronary cusp

Movie clip S5. 3DTEE with multiplane reconstruction at the level of the aortic root demonstrates the massive thrombus involving both the left and the noncoronary cusps of the aortic valve. Abbreviations: LA, left atrium; LCC, left coronary cusp; LV, left ventricle; NCC, noncoronary cusp; RCC, right coronary cusp; RV, right ventricle

Movie clip S6. 3DTEE with multiplane reconstruction at the level of the aortic root demonstrates the massive thrombus (arrow) involving both the left and the noncoronary cusps of the aortic valve. This video demonstrates the incremental value of systematic cropping through the 3D dataset for complete evaluation of the thrombus size and location. Abbreviations: LA, left atrium; LCC, left coronary cusp; LV, left ventricle; NCC, noncoronary cusp; RCC, right coronary cusp; RV, right ventricle

Movie clip S7. 3DTEE demonstrates thrombus (arrow) in the left and noncoronary cusps and its anatomic relations to the surrounding structures. Abbreviations: LA, left atrium; LCC, left coronary cusp; NCC, noncoronary cusp; RA, right atrium; RCC, right coronary cusp

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