Successful removal of a potentially lethal left atrial thrombus detected by transesophageal echocardiography following the removal of a left ventricular assist device inflow cannula

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Abstract

The left ventricular assist device (LVAD) is a battery-operated, mechanical pump-type device that helps in maintaining the pumping ability of a failing heart. Thromboembolism poses a significant risk during and after LVAD implantation. It occurs in up to 35% of patients with adverse sequelae. We present the case of a 75-year-old man who underwent coronary artery bypass graft surgery and LVAD implantation for acute myocardial ischemia and severe left ventricular dysfunction. However, subsequent transthoracic echocardiographic examination revealed an LVAD thrombus, and LVAD removal was suggested following the failure of thrombolytic therapy. After the LVAD cannula was removed, transesophageal echocardiography (TEE) revealed a residual thrombus in the left atrium. Thrombectomy was successfully performed by opening the left atrium with cardiopulmonary bypass. We believe that TEE monitoring aided the implantation and removal of the LVAD device. In this case, we found that TEE not only helped in monitoring the ventricular function but also in detecting other problems such as the residual thrombus. We strongly recommend TEE monitoring during the entire LVAD-removal procedure, particularly for patients who need to undergo LVAD removal because of thrombosis formation.

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1. Introduction

The left ventricular assist device (LVAD) is a battery-operated, mechanical pump-type device that is usually used as a so-called “bridge to transplant” for severe heart failure patients. However, there are a few problems related to LVAD usage, of which inflow and outflow cannula obstruction induced by thrombus formation is one of the most severe and frequently observed. LVAD thrombogenicity is mainly due to the anticoagulation-resistant surface thrombin activity harbored by LVAD Dacron grafts. This complication can lead to death if the thrombus causes obstruction in the flow between the concurrent LVAD and a failed heart and then circulatory collapse follows.

Transesophageal echocardiography (TEE) is the most commonly used technique for the evaluation of obstructed LVAD conduits. Under TEE observation, pump flow and performance can be optimized by correct positioning of the cannula in LVAD recipients. Moreover, TEE may help in identifying detailed morphologic characteristics of an intra-cardiac mass lesion, such as a thrombus.

Here, we present the case of a patient with a lethal left atrial thrombus that was detected by TEE after the removal of the LVAD cannula. Under TEE monitoring, the LVAD was successfully removed, and the patient was uneventfully discharged later.

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2. Case report

A 75-year-old man with a history of hypertension was admitted to the emergency department because of acute chest pain and shortness of breath. The patient went into shock when his blood pressure dropped to 76/48 mmHg. An emergency electrocardiographic examination revealed sinus rhythm with ST segment depression and T-wave inversion in leads V3-6. Serum analysis revealed elevated levels of cardiac enzymes [creatine kinase (CK), 1245 U/L; MB isoenzyme of CK, 101 U/L; troponin-I, 39 ng/mL]. Emergent coronary angiography was performed, revealing severe coronary artery disease with triple vessel disease [LAD-P total occlusion, LCX-P 90% stenosis, - D 70% stenosis, - OM3 95% stenosis, RCA-P to - M segmental stenosis, with collaterals to LAD], apical aneurysm, acute myocardial infarction, and poor left ventricular (LV) function. The LV ejection fraction was extremely low, about 13%. Because the patient had severe stenosis of the coronary artery, stent insertion was considered relatively difficult and risky. Surgical intervention was suggested, and a cardiovascular surgeon was consulted.

The LV ejection fraction improved to 29% after several days of medical treatment and intra-aortic pump support. However, transthoracic echocardiography (TTE) revealed moderate mitral regurgitation, which resulted from the dilated mitral annulus with a 10 cm × 8 cm LV aneurysm present. Considering the patient’s poor heart function and that there were already collaterals from the RCA to the LAD, the surgeon decided to revascularize only the LCX to shorten the operation time for to get the most benefit for this patient. Coronary artery bypass graft (CABG) surgery [gastroepiploic artery to the first obtuse marginal branch], left ventricular aneurysmectomy, and mitral valve annuloplasty (28 mm Edwards IMR ETlogix annuloplasty ring; Edwards, Irvine, CA, USA) were scheduled. Because of poor LV function and the high dose of inotropic agents administered during cardiopulmonary bypass removal, an LVAD (Levitronix CentriMag Blood Pump; Levitronix, Waltham, Mass, USA) was chosen for circulatory support instead of extracorporeal membrane oxygenation because of having fewer complications and better outcome. The LVAD was implanted with inflow from the left atrium and outflow to the ascending aorta; the flow was maintained at approximately 3.6 L/min. However, the LVAD flow occasionally dropped to 1.51 L/min, and TTE revealed a mass over the inflow cannula 3 weeks after implantation (Fig. 1). The patient received thrombolytic therapy, but it was ineffective, and therefore the LVAD had to be removed. Before the procedure, TEE showed an organized thrombus of diameter 3.52 cm × 1.71 cm encircling the LVAD inflow cannula in the left atrium (Fig. 2). The entire procedure of LVAD removal under general anesthesia was performed under real-time TEE monitoring. A lethal thrombus was detected in the left atrium after the LVAD cannula was removed (Fig. 3). Cardiopulmonary bypass was performed immediately, and the thrombus was successfully removed by opening the left atrial chamber. TEE showed no residual thrombus in the left atrium (Fig. 4).

3. Discussion

LVAD is increasingly used as a bridge to cardiac transplantation,7,8 for destination therapy in patients with end-stage heart failure and for postcardiotomy cardiogenic shock occurring in 2% to 6% of all patients undergoing CABG or valvular surgery.9 However, LVAD usage often poses complex hematologic challenges, including thromboembolism, which can lead to death.1 TTE or TEE can be used for thrombus detection,10 and further management including thrombolytic therapy or surgical intervention can be carried out.

LVAD recipients often have increased levels of platelet release and thrombin activity during device implantation. LVAD Dacron grafts harbor anticoagulation-resistant surface thrombin activity, which may play an important role in LVAD thrombogenicity.2 There is evidence of increased thrombin generation and fibrinolysis in LVAD recipients, despite
a normal prothrombin time, activated partial thromboplastin time, and platelet count. Thus, thromboembolism is a significant problem in LVAD implantation; it occurs in up to 35% of patients with adverse sequelae. In an expected short-term-use LVAD system, continuous intravenous heparin will be prescribed to keep activated clotting time between 200 and 250 seconds. Even though thromboembolism is a significant risk, and it may be related to the relationship between cannula size and flow rate, more importantly, it is related to the concurrent activation of the coagulation and fibrinolytic systems.

In our case, we chose the left atrium to be the inflow site of the LVAD because the operator could instantly establish an effective circulation system and also because the purpose was for short-term assistance of LV function. The inflow site and the native heart function can affect the flow rate; Tevaearai et al concluded that drainage through the left atrium (LA) or the LV was similar when CVP was set at 8 mmHg, and increasing CVP to 14 mmHg allowed for better drainage through the LV cannula. Due to easier collapse of LA and there is being lower flow through the LVAD inflow cannula from the LA compared to from the LV, the risk of thromboembolism seems higher in the LVAD recipients with the inflow from the LA. That may be one reason for our patient receiving heparin therapy following LVAD implantation; there was still a thromboembolic event occurring. Some studies report that thrombolytic therapy has been used to successfully treat thrombi in LVAD recipients, while this therapy has been found to be ineffective in some other studies. Similarly, our patient received heparin for prophylaxis and thrombolytic therapy following thrombus detection, but the result was unsatisfactory.

Although TTE revealed the lesion before the operation, the detailed relationship between the mass lesion, left atrium, and LVAD inflow cannula was unclear. Instead, TEE can provide more information on the nature of a lesion. In a study by Srichai, TEE showed a higher sensitivity (40% ± 14%) than TTE (23% ± 12%) for thrombus detection in 160 patients with ischemic heart disease and thrombus formation. Many studies have proven the greater efficiency of TEE compared to TTE in diagnosing cardiovascular diseases; TEE allows identification of detailed morphologic characteristics of intracardiac mass lesions. In our case, TEE monitoring during the whole procedure was especially effective because TEE access is closest to the LA.

Thus, as TEE is a powerful tool for heart evaluation, some studies have advocated the efficacy of TEE monitoring during
LVAD removal.\textsuperscript{19} For LVAD removal, TEE is effective not only in evaluating ventricular function but also for detecting problems such as a residual thrombus following LVAD decannulation.\textsuperscript{19} One study with four cases of LVAD malfunction\textsuperscript{20} concluded that TEE played a pivotal role in the clinical management of LVAD failure. TEE can be used not only to assess the patency and position of the LVAD cannula but also to examine the source of the thromboembolic material. In our case, although the LVAD removal procedure did not initially require cardiopulmonary bypass, we decided to use TEE monitoring for evaluating the ventricular function and the nature of the thrombus. This led to the accidental detection of the thrombus in the left atrium retained after LVAD removal, which could have led to a lethal complication.

According to the Practice Guidelines for Perioperative Transesophageal Echocardiography (Anesthesiology 2010; 112:1-1.), TEE monitoring is strongly recommended during modern open-heart surgery, including LVAD implantation. However, TEE is not routinely used during the procedures of cannulation removal of circulatory assist device, such as intraaortic balloon, extracorporeal membrane oxygenation device, or ventricular assist device. These procedures are considered relatively simple, and some even can be performed at bedside. There could be a catastrophe if thrombosis formed around the cannula and residual thrombosis was left in the heart after cannula removal. Therefore TEE monitoring in these procedures becomes more important. In our case, opening the left atrium was not in the surgical plan of LVAD removal in the beginning. If we had not used TEE as a monitoring modality, the residual thrombus would not have been detected and lethal complication might have happened. Furthermore, the inflow cannula was inserted in the LA, which could be estimated more precisely by TEE, especially when there were problems such as decreased inflow rate or mechanical obstruction. Through this experience, we strongly recommend that TEE should be routinely used in LVAD removal, especially in cases with thrombus formation, and also should be considered in the perioperative period when LVAD malfunction happens.

References


