Emergent Pulmonary Thromboembolectomy and Atrial Septal Aneurysmectomy for Intracardiac Impending Paradoxical Embolism: An En Bloc Approach to Prevent Clot Embolism and Facilitate Repair

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INTRODUCTION

Although a patent foramen ovale (PFO) is relatively common, confirmed reports of thrombus entrapped within a PFO are uncommon. Management of impending paradoxical embolism (IPE), also called a thrombus in transit, lacks consensus but includes systemic anticoagulation (e.g., heparin), systemic thrombolysis, or surgical thrombectomy. We present a case of IPE diagnosed with intraoperative transesophageal echocardiography (TEE) as well as a novel en bloc approach to atrial septal aneurysmectomy to minimize embolism and facilitate repair of the interatrial septum. Timely use of intraoperative TEE may aid in diagnosis and help guide the surgical approach to minimize embolic risk with an IPE.

CASE REPORT

A 66-year-old male presented with chest pain and dyspnea that had become progressively worse over five days. His comorbidities included hypertension, morbid obesity (body mass index 60 kg/m²), obstructive sleep apnea, stage IV chronic kidney disease, and cigarette smoking. There was suspicion of pulmonary embolism (PE), however due to his severe renal dysfunction a CT angiogram was not performed. D-Dimer was elevated (>2000 ng/mL), to minimize embolism and facilitate repair of the interatrial septum.
NT-pro BNP was 17,053 pg/mL, and troponin was 0.09 mg/mL with no significant change at 6 hours. He had a leukocytosis of 12.3 × 10^9/L, prothrombin time of 12.4 seconds with an international normalized ratio (INR) of 1.1, and creatinine of 3.2 mg/dL with an estimated glomerular filtration rate of 20 mL/min/BSA. Duplex ultrasound confirmed deep vein thromboses (DVT) of the popliteal and calf veins of the left leg. A transthoracic echocardiogram (TTE) demonstrated a leftward bowing interatrial septum and large mobile thrombus within the right and left atria concerning for thrombus in transit through a PFO. Due to body habitus and image quality available, the interatrial septum could not be interrogated or defect confirmed on transthoracic imaging. His TTE also demonstrated moderate right ventricular (RV) enlargement with moderate to severe strain, an estimated RV systolic pressure of 81 mmHg (systemic systolic pressure 115 mmHg), and normal left ventricular (LV) size and function with an ejection fraction of 55%. Experts in vascular medicine and cardiovascular surgery were consulted. The patient proceeded directly to the operating room for emergent pulmonary embolectomy and repair of the suspected interatrial defect under cardiopulmonary bypass (CPB) with placement of a caval filter.

On arrival to the operating room, the patient was alert and communicative and hemodynamically stable with a systemic blood pressure of 137/94 mmHg. The patient was induced under general anesthesia and standard monitoring lines were placed. Intraoperative TEE demonstrated an evolving IPE extending from the pulmonary artery, through the tricuspid valve and right atrium (RA), and crossing an aneurysmal interatrial septum into the left atrium (LA) through a PFO [Video 1]. In the LA, the mobile thrombus could be seen entering through the mitral valve during ventricular diastole, however no definite thrombus was visible in the LV [Video 2].

Sternotomy was performed uneventfully and the patient was cannulated with a 22 French aortic cannula and bicaval venous cannulas, along with an aortic root vent. CPB was initiated, and he was cooled to 34 degrees centigrade. The aortic cross clamp was placed, and cold blood antegrade cardioplegia was delivered to achieve diastolic arrest.

The RA was entered and the atrial septal aneurysm containing the entire fossa ovalis and transatrial thrombus were resected en bloc [Figure 1]. On examination, the LA and LV did not contain residual thrombus. The atrial septal defect was repaired with bovine pericardium and continuous 3-0 Prolene suture. The aortic cross clamp was removed with a total clamp time of 18 minutes. The patient spontaneously returned to sinus rhythm. Main and bilateral pulmonary artery embolectomy was then performed with typical approach. The patient was successfully weaned from cardiopulmonary bypass on epinephrine, norepinephrine, and vasopressin infusions and inhaled nitric oxide. Due to ongoing coagulopathy requiring correction with transfusions, the chest was left open and caval filter placement was deferred. In the intensive care unit (ICU) he developed worsening renal function and acidosis and continuous renal replacement therapy (CRRT) was initiated for acute on chronic kidney injury. After improvement of his coagulopathy, he was commenced on warfarin therapy and bridged with a heparin infusion. On post-operative day (POD) 1 his chest was closed and a caval filter was placed. By POD 4 he was weaned from all vasoactive medications. He was successfully extubated on POD 5, transitioned from CRRT to intermittent hemodialysis on POD 7, and transferred out of the ICU on POD 8.

The patient experienced a prolonged hospitalization because of his multiple comorbidities but was eventually discharged on warfarin anticoagulation. At 5-month follow-up, transthoracic echocardiography demonstrated mild RV enlargement with normal function. There was trivial tricuspid valve regurgitation with unmeasurable peak tricuspid regurgitation velocity for pulmonary artery systolic pressure calculation.

**DISCUSSION**

Although the presence of a PFO is common in the general population (about 20%), confirmed reports of thrombus entrapped within a PFO are uncommon in the literature. The first reported IPE, occurred in 1985 using transthoracic echocardiography. Reports have increased with widespread use of both transthoracic and transesophageal echocardiography in the intervening years; however, the condition likely remains underdiagnosed overall.

As outlined by Myers et al., the diagnosis of a paradoxical embolism requires specific conditions; there must...
be a DVT or PE, a communication between the left and right circulation, objective evidence of systemic embolism (clinical, radiographic, echocardiographic etc.), and the presence of a pressure gradient promoting a right to left shunt.\[^4\]

Management strategies for an IPE lacks consensus in the literature. Options include systemic anticoagulation, systemic thrombolysis, or surgical thrombectomy.\[^3,4\] In some cases, placement of a vena caval filter may also be used.\[^3\]

This case highlights a unique surgical approach to an IPE to minimize the risk of systemic embolization. Rather than risk fracture by pulling the thrombus through the PFO followed by septal repair, we removed the entire fossa ovalis along with the thrombus en bloc to prevent embolism with crossclamp removal. This approach both reduced the risk of clot disruption and facilitated the repair of the clinically significant septal aneurysm and PFO.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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