Role of hybrid operating room in surgery for the right atrial thrombus, pulmonary thrombi, and ventricular septal rupture after myocardial infarction

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ABSTRACT

Free-floating right heart thrombi are uncommon and need emergency treatment in view of their tendency to dislodge and cause pulmonary embolism. We report a successful surgical management of a patient who had large mobile right atrial thrombus, bilateral pulmonary thrombi, coronary artery disease, and postmyocardial infarction ventricular septal rupture (VSR). The patient underwent coronary angiography, inferior vena cava filter placement, removal of thrombi from the right atrium and pulmonary arteries, repair of VSR, and coronary artery bypass graft surgery in a hybrid operating room.

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INTRODUCTION

Free-floating right heart thrombi (FRHTs) are a rare phenomenon, encountered in approximately 7–18% of the patients with pulmonary embolism (PE).[1] They can embolize at any moment, and are associated with a very high (>40%) mortality rate.[2] They need either medical therapy in the form of anticoagulation/thrombolysis, or surgical evacuation as treatment, and/or placement of an inferior vena cava (IVC) filter as a preventive measure to reduce neurological complications. Ventricular septal rupture (VSR) is a rare but serious complication of myocardial infarction, associated with a high mortality.[3] We report the management of a case who underwent coronary angiography, placement of an IVC filter, removal of the right atrial thrombus, repair of VSR, removal of pulmonary thrombi under deep hypothermic circulatory arrest, and coronary artery bypass graft surgery in the hybrid operating room (OR) under a single anesthetic.

CASE REPORT

A 62-year-old man presented to the emergency room with the chief complaints of chest pain, breathlessness, and pain in the legs for the past 15 days. He had suffered an anterior wall myocardial infarction 15 days ago, and was thrombolysed with streptokinase. There was a history of swelling and pain in the lower

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limbs 1 year and 3 months ago, which was diagnosed as deep vein thrombosis (DVT). There was no history of hypertension, diabetes mellitus, or smoking. Twelve-lead electrocardiogram was suggestive of sinus tachycardia and anterior wall myocardial infarction. Two-dimensional (2D) transthoracic echocardiography showed a large free-floating tubular thrombus in the right atrium (RA) prolapsing into the right ventricle (RV) with each cardiac cycle, dilated RA and RV, an apical VSR measuring 1.2 cm with L-to-R shunt, RV systolic dysfunction, severe tricuspid regurgitation, RV systolic pressure of 70 mmHg, dilated IVC with <50% collapsibility, and left ventricular ejection fraction of 40%. Unfractionated heparin therapy (500 IU/h) was started.

Lower limb venous Doppler showed normal color flow and waveform in bilateral common femoral, superficial femoral, profunda femoris, popliteal, and anterior/posterior tibial veins, with no evidence of DVT at the time of admission. Computed tomography of the chest showed bilateral pleural effusion, a large thrombus in RA, and intraluminal filling defects suggestive of thrombi in distal branch pulmonary arteries (PAs) extending into the upper and lower lobar arteries and their segmental branches [Figure 1]. Cardiothoracic and vascular surgical consults were obtained, and it was planned to evacuate thrombi from RA and PA, and to repair the VSR, after placing an IVC filter. All routine laboratory investigations were within normal limits, except prolonged activated partial thromboplastin time (64 s, normal 24.4–32.2 s) and elevated D-dimer value (2.5 μg/ml, normal <0.5 μg/ml). On the basis of objective risk factors (EuroSCORE 9.03%), a high-risk informed consent was taken.

The patient was taken to the hybrid OR with Artis Zeego C-arm imaging system in place [Axiom Artis Zeego, Siemens AG, Germany, Figure 2]. Under standard cardiac monitoring, general anesthesia was induced and 3D transesophageal echocardiography (TEE) probe (iE33; Philips Medical Systems, Bothell, WA, USA) was inserted. The right internal jugular vein was cannulated using midesophageal bicaval view on TEE, taking caution to avoid touching RA thrombus with the guidewire or central venous catheter. Intraoperative TEE findings were consistent with preoperative echocardiographic findings. In addition to RA thrombus [Figure 3 and Video 1] and apical VSR, distal right PA was seen full of thrombus [Figure 4], and RV systolic dysfunction was evident (tricuspid annular plane systolic excursion of 0.8 cm, normal >1.6 cm) [Figure 5]. Coronary angiography was done which showed 99% occlusion of the

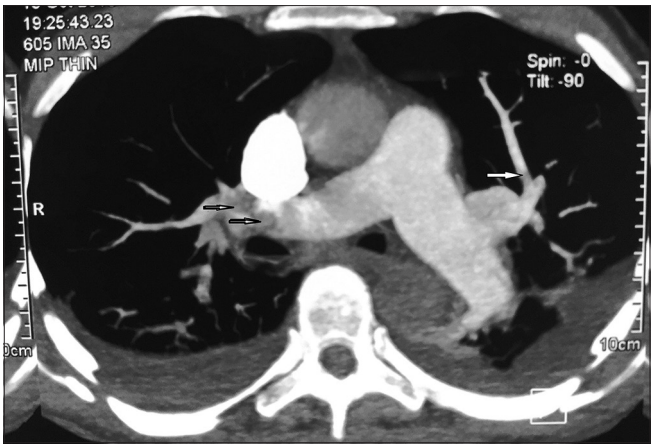

Figure 1: Computed tomography scan showing thrombi in the right pulmonary artery (black arrows) and apical branch of the left pulmonary artery (white arrow)

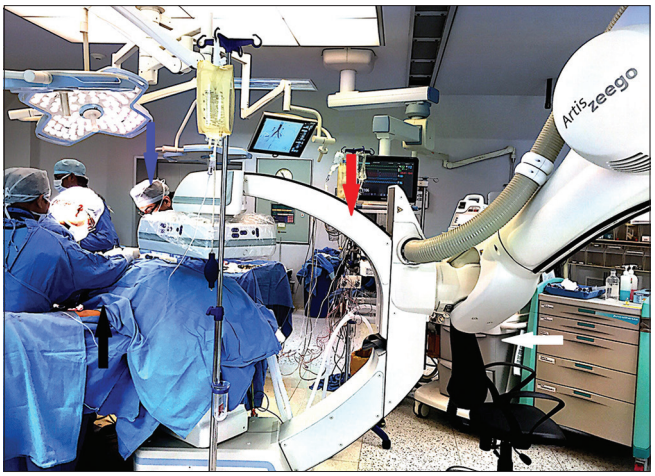

Figure 2: Image of hybrid operating room showing Axiom Artis Zeego C-arm imaging system (red arrow), anesthesia workstation (white arrow), patient (black arrow), and surgeon (blue arrow)

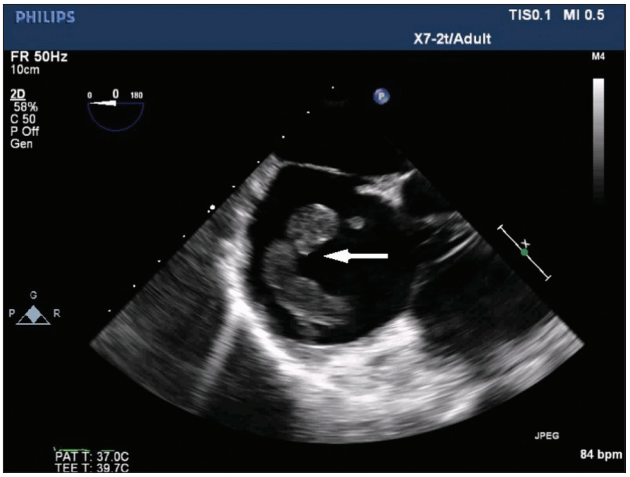

Figure 3: Two-dimensional transesophageal echocardiographic view showing free-floating thrombus in the right atrium (arrow)

proximal left anterior descending artery. An IVC filter (G2x Bard, San Francisco, CA, USA) was deployed in the infrarenal position via femoral venous approach using fluoroscopic guidance. Chest was opened, and under hypothermic cardiopulmonary bypass (CPB) and cold cardioplegic arrest, the thrombus measuring 1.2 cm × 4.7 cm was removed "en masse" from RA [Figure 6], and VSR was repaired using Teflon felt patch through the left ventricular apical approach. Then, the patient was cooled to 18°C for deep hypothermic circulatory arrest. By employing the standard cerebral protective measures, bilateral PAs were opened and thrombi were removed from their lobar and segmental branches. While rewarming was in process, saphenous vein graft was anastomosed to the left anterior descending artery. Weaning from CPB was assisted by intra-aortic balloon counterpulsation and inotropic support (dobutamine 5 μg/kg/min, epinephrine 0.05 μg/kg/min, and norepinephrine 0.1 μg/kg/min). Post-CPB TEE evaluation revealed no thrombus in RA [Video 2] or PA, no residual VSR, and mild tricuspid regurgitation. The durations of circulatory arrest, aortic cross clamp, CPB, and total surgical procedure were 24 min, 119 min, 150 min, and 385 min, respectively. Postoperative course was uneventful without any neurologic deficit. The trachea was extubated on day 2, intra-aortic balloon catheter was removed on day 4, and the patient was discharged from the hospital on day 12 with oral anticoagulant therapy.

DISCUSSION

Hybrid ORs are likely to become a key feature of more institutions as the number of patients undergoing hybrid procedures increases. The adjustable isocenter of hybrid room enables rotational angiography of all parts of the body. It also allows faster and more precise catheter navigation through 3D road mapping that superimposes 3D reconstruction onto live 2D fluoroscopy images. The commonly performed hybrid cardiovascular procedures include complex coronary artery procedures, transcatheter aortic valve implantation, thoracic aortic aneurysm repair, and congenital cardiac procedures.[4] Hybrid OR allowed us to carry out combined catheter-based intervention (coronary angiography and IVC filter placement) and open-heart surgery under a single anesthetic. An essential component of the infrastructure of a modern cardiovascular service, hybrid OR, is being recognized increasingly by clinicians, with its potential benefits of enhanced patient safety, elimination of staging between procedures, better resource utilization, and decreased length of stay.

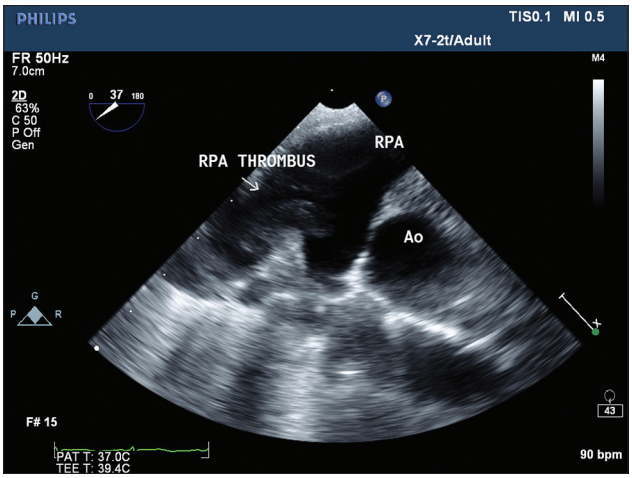

Figure 4: Midesophageal ascending aorta short axis view showing thrombus in the right pulmonary artery. RPA: Right pulmonary artery, Ao: Aorta

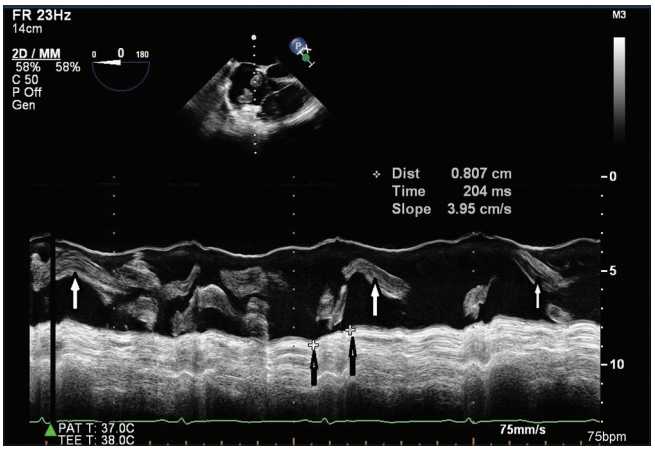

Figure 5: M-mode echocardiography showing tricuspid annular plane systolic excursion of 0.8 cm (black arrows) and thrombus in the right atrium (white arrows)

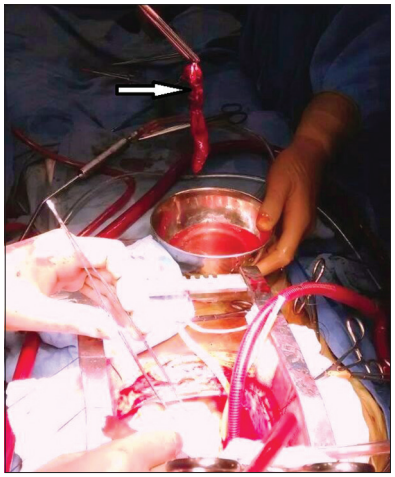

Figure 6: Large mobile thrombus (1.2 cm × 4.7 cm) removed "en masse" from the right atrium

FRHTs are an infrequent phenomenon associated with a high mortality, and a potential source of embolization that warrants immediate surgical evacuation. They may develop within the heart or more commonly, originate from peripheral venous system that lodges in the right heart on their way to the lungs. They are generally diagnosed when echocardiography is performed in patients with suspected or proven PE. In the presence of FRHTs, the incidence of PE is 97%.[5] Differential diagnoses of FRHTs include Chiari network, persistent eustachian or thebesian valves, atrial septal aneurysms, intracardiac tumors, or vegetation. The largest single-center series published so far ($n = 38$) has labeled FRHTs as an extreme therapeutic emergency.[5] Patients with FRHTs are more hemodynamically compromised, as suggested by their lower systemic pressure, tachycardia, and frequent RV hypokinesia than patients without FRHTs.[6] A recently published multivariate analysis has concluded that advanced age, hemodynamic instability, and history of recurrent PE have a statistically significant effect on the mortality.[7]

Investigators have recommended either thrombolysis or urgent surgical treatment for FRHTs, although prospective data of optimal treatment are lacking.[8,9] The choice of treatment depends on additional factors, and this patient underwent surgical therapy because he required surgery for coronary artery disease, PE, and VSR as well. DVT and PE represent two clinical presentations of a single disease process and share the same predisposing factors. Free-floating iliofemoral or IVC thrombus has been associated with 27–60% risk of PE, and therefore it is considered an indication for IVC filter placement.[10] In general, IVC filters are indicated in patients (i) who cannot tolerate anticoagulant therapy, or (ii) for whom anticoagulant therapy is ineffective/contraindicated, or (iii) for those with severe cardiopulmonary disease undergoing major surgery followed by immobilization such as this patient.[10]

The American Society of Echocardiography guidelines consider 3D echocardiography superior to 2D technique for the assessment of intracardiac masses as it acquires pyramidal volume of information that can be visualized from different angles.[11] Although TEE is not considered gold standard for the diagnosis of PE, it compares well with computed tomography when it is acute and central. TEE findings consistent with acute PE include RV dilatation, RV hypokinesia, and regional wall motion abnormalities of RV free wall.

CONCLUSION

Successful surgical management of RA thrombus, PA thrombi, coronary artery disease, and postinfarct VSR could be done under a single anesthetic in a hybrid OR. TEE played a pivotal role during the insertion of central lines, for the confirmation of preoperative echocardiographic findings, and to assess the adequacy of surgical repair.

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Conflicts of interest

There are no conflicts of interest.

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