

Simultaneous pulmonary embolization and myocardial infarction with ST-segment elevation related to paradoxical embolization: Significance of patent foramen ovale

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Paradoxical embolism is the clinical condition in which the embolic material from the venous system is transmitted to the arterial system through an intracardiac shunt — a patent foramen ovale (PFO) or an ostium secundum atrial septal defect. Sometimes a thrombus may also get entrapped in a PFO creating a risk of a peripheral arterial embolism. It is a rare and unconventional source of acute arterial occlusion. It can cause a stroke, visceral vessel embolism, and in some cases a myocardial infarction [1, 2].

A 36-year-old man without significant cardiovascular diseases was admitted to the hospital with an acute anterior-inferior ST-segment elevation myocardial infarction (Figure 1A) resulting from an embolism in the left anterior descending artery (LAD) (Figure 1B). The dominant clinical symptoms were dyspnea, and chest pain. Vital signs were as follows: (1) oxygen saturation level: 92%; (2) blood pressure: 90/50 mm Hg; and (3) heart rate: 120/min. In laboratory tests, high D-dimer levels were detected (7454 ng/ml; norm: <500) and elevated cardiac troponin levels were found (>25 ng/ml; norm: <0.016). While performing a routine transthoracic/transesophageal echocardiography assessment, we found: (1) right ventricular enlargement (parasternal long-axis view): 3.9 cm; (2) elevated tricuspid regurgitation peak gradient >55 mm Hg; (3) flattening of the interventricular septum: D-shaped left ventricle (Figure 1D); and (4) a thrombus straddling the PFO (Figure

1D–E). The computed tomography pulmonary angiography confirmed a central pulmonary embolism with a thrombus formed in the right pulmonary artery and complicated by a thrombus straddling the PFO (Figure 1C). The coronary angiography demonstrated total occlusion of the LAD (Figure 1B). A percutaneous mechanical aspiration thrombectomy attempt to remove the thrombus from the LAD was unsuccessful. Only small fragments of the thrombus were removed.

The patient underwent cardiac surgery by sternotomy, with extracorporeal circulation, which involved atriotomy with the removal of all available thrombi from lobar and segmental pulmonary arteries, PFO, and the LAD artery (Figure 1F–G). The patient received therapeutic doses of unfractionated heparin monitored with activated partial thromboplastin time. Intraoperative venography of iliac veins and the inferior vena cava showed no thrombus. At the same time, a temporary inferior vena cava filter was used. Due to the patient's serious condition and emergency surgery, Doppler-ultrasonography of lower extremities was not performed.

Thrombolytic treatment was not used due to the risk of fragmentation of the thrombus stuck in the PFO. The patient died in the operating theater of cardiac arrest due to pulseless electrical activity despite successful revascularization of the LAD with the left internal mammary artery coronary artery bypass graft, as a result of concomitant pulmonary

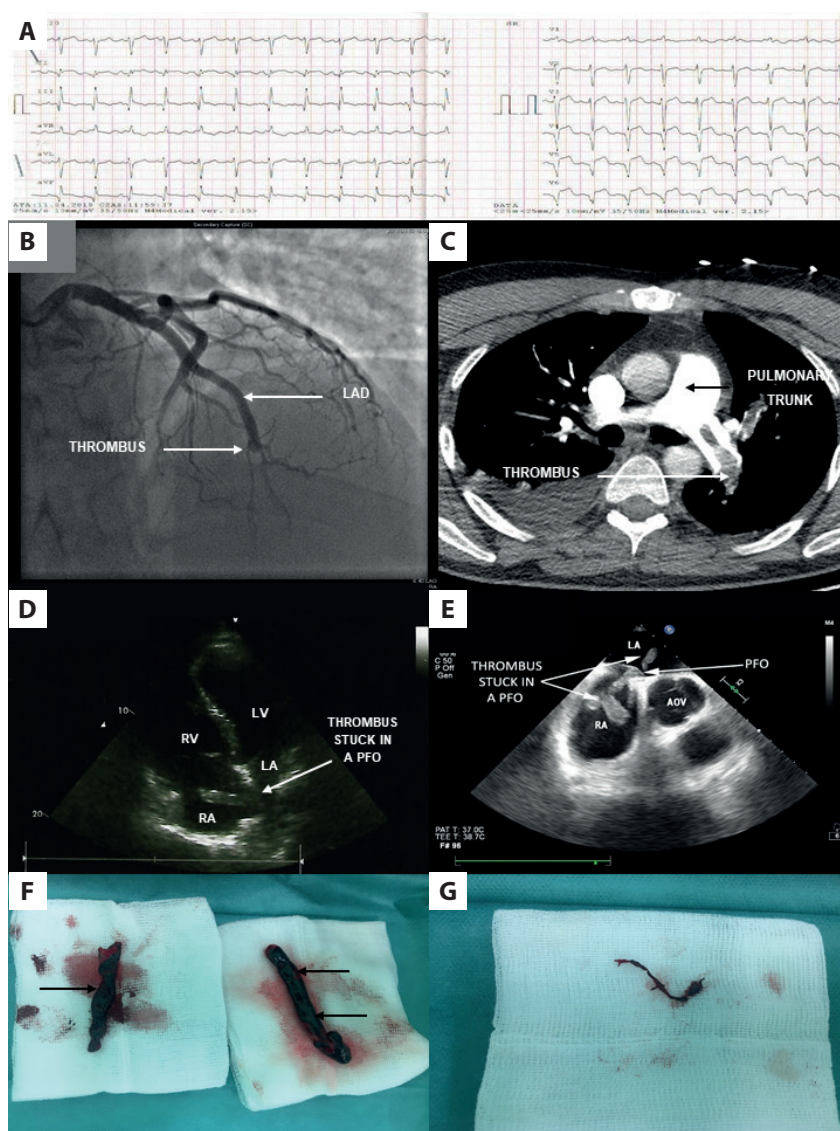


Figure 1. **A.** Electrocardiogram on admission: SR 120/min, right deviation of the heart electric axis, ST-segment elevation and pathological Q wave in precordial V4–V6 leads, slight ST-segment elevation and pathological Q wave in inferior leads II, III, aVF. **B.** Coronary angiography: massive thrombotic burden in the middle part (seventh segment) of the LAD (the arrow is pointing at the proximal part of the massive thrombus). **C.** Angio-CT image: a massive thrombosis of the pulmonary artery main trunk; the arrow is pointing at the thrombus (horizontal view). **D.** Transthoracic echocardiography: the thrombus trapped in a PFO extending into the RA and LA, enlarged RV; the arrow is pointing at the part of the thrombus in the RA and LA (modified apical four-chamber view). **E.** Transesophageal echocardiography: the thrombus stuck in a PFO with a mobile part in the LA; the arrows are pointing at the parts of the thrombus in the RA and LA (high transesophageal view). **F.** The thrombus removed from the PFO — single arrow; the thrombus removed from the lobar pulmonary artery — double arrows. **G.** The thrombus removed from the LAD

Abbreviations: CT, computed tomography; LA, left atrium; LAD, left anterior descending artery; LV, left ventricle; PFO, patent foramen ovale; RA, right atrium; RV, right ventricle; SR, sinus rhythm

embolism (PE) and massive embolic myocardial infarction. An intra-aortic balloon pump had no effect.

The mechanism of paradoxical embolism formation in PE patients is provoked by increased pressure in the pulmonary arteries, right ventricle, and right atrium resulting in a reversal of the blood shunt through a PFO [3]. The course of PE and paradoxical embolism can be multi-phased and may appear on consecutive days of hospitalization. A thrombus trapped in the PFO can be asymptomatic and can remain unnoticed, making it exceptionally difficult to take preventative measures and set an effective treatment.

A diagnosis of PE should lead to obligatory echocardiographic screening for the presence of both right heart/pulmonary arteries thrombus in transit and the presence of a PFO or thrombus stuck in the PFO [4]. When present, it is necessary to search for the symptoms of paradoxical embolism. Making the diagnosis at an early stage makes it possible to remove the thrombus and close the PFO by car-

diac surgery, which constitutes a recommended procedure [5]. In the case of crossed embolism, taking a therapeutic approach (thrombolysis/cardiac surgery) should be individualized depending on the case because there are no direct guidelines for the treatment in such clinical situations [4, 5]. Rescue percutaneous aspiration thrombectomy of the coronary artery has limited effectiveness in the treatment of venous thrombus occlusion due to its size and structure (so-called red thrombus: erythrocyte-rich), as opposed to the well-documented high effectiveness of classic arterial thrombus aspiration in an unstable atherosclerotic plaque (so-called white thrombus: platelet-rich). Still, a vast armamentarium of interventional devices is left as a second-line treatment option and recommended mostly when systemic thrombolysis fails or is contraindicated. One of the promising options is the combined use of the AngioVac system (AngioDynamics, Inc., Latham, NY, US) and SENTINEL™ cerebral protection system (SCPS; Boston Scientific, Marlborough, MA, US) [5]. This device has a potential role in

percutaneous treatment of thrombus in transit, especially in patients with contraindications for thrombolysis and patients who may not be eligible for surgery [5].

The presence of PFO poses a risk of crossed embolism in patients with deep-vein thrombosis and PE. This is an important argument for prophylactic PFO closure or for administering chronic anticoagulant therapy [2, 5]. However, currently, PFO occlusion in patients with suspicion of cerebral or noncerebral embolism is neither clearly nor definitely established.

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