The Cardiothoracic Surgeon

CASE REPORT

Open Access

# Anesthetic management and the role of TEE in the entrapment of a paradoxical embolus by a patent foramen ovale

Jevaughn S Davis*, Jessica Zvara and K. Gage Parr

## Abstract

**Background:** A paradoxical embolism arises when a venous thrombus passes through a cardiac right to left shunt and enters the arterial circulation. This can manifest as cardiovascular ischemia, cerebrovascular insults, increased right ventricular pressure, and/or volume overload leading to signs and symptoms of heart failure. While rare, paradoxical emboli carry high mortality and morbidity if diagnosis is missed and/or treatment is delayed. Transesophageal echocardiography can be diagnostic. Initial treatment revolves around anticoagulation and/or thrombolysis to prevent clot propagation. However, for clots in transit, emergent surgical removal is often necessary. Anesthetic induction can be tricky given the potential for rapid deterioration and the need to avoid increased right sided pressures and further clot migration.

**Case presentation:** In this report, we present a 72-year-old obese female with a history of hypertension, hyperlipidemia, gout, and diabetes found to have a paradoxical embolism caught in transit, trapped in a patent foramen ovale, and managed surgically. We describe the role of intraoperative transesophageal echocardiography in successfully treating this patient.

**Conclusions:** TEE plays an important role in the diagnosis and management of paradoxical PE. It can detect right and left heart thrombi and intracardiac shunts, can help in the successful closure of intracardiac shunts, and can impact intraoperative surgical decision making.

**Keywords:** Transesophageal echocardiography, Patent foramen ovale, Paradoxical embolus, Thrombus in transit, Anesthetic management, Case report

## Background

Paradoxical embolism (PDE) refers to the transit of clots from the venous system to the arterial system via a right to left shunt. Diagnosis is contingent on the presence of a venous thrombus, an arterial embolus, and a shunt between the right and left heart, usually a patent foramen ovale (PFO). In addition, thrombus traveling between right and left heart or evidence for reversal of intracardiac blood flow should be seen [1]. Unfortunately, for many patients, the diagnosis is made postmortem due to the high mortality and morbidity. Despite a high incidence of PFO in adult populations (27–30%), paradoxical embolism is a rare event [2]. Paradoxical emboli have a prevalence of 2–4% in the general population and account for only 2% of all arterial emboli [1].

There are three types of cardiac thrombi that can be distinguished using echocardiography [3]. Type A is the most common and is a result of deep venous thrombosis embolization. These thrombi tend to be elongated, highly mobile, and have a "worm-like" appearance [3]. Type B thrombi originate in the atria or ventricle, are ovoid in shape, and are firmly attached to a chamber wall [3].

*Correspondence: JevaughnDavisERAS@gmail.com

Department of Anesthesiology and Critical Care, George Washington School of Medicine and Health Sciences, Washington DC 20037, USA

Type C thrombi are rare, very mobile, and mimic cardiac myxomas on imaging [3].

Pulmonary embolus (PE) occurs when one of these types of thrombi travels to the pulmonary arteries (PA) and the lungs. PE is associated with significant morbidity and mortality. This is increased when a right heart clot is in transit. In acute PE, a clot in transit is rarely seen, but if seen, the estimated mortality is 21–28% in treated populations and 80–100% in untreated populations [1–4]. Paradoxical emboli occur when a clot passes through an intracardiac shunt, to the left side of the heart and into the systemic circulation. A PFO is the most common adult intracardiac shunt [4]. A PFO is an interatrial fetal circulation remnant that occurs when the septum primum and septum secundum fail to fuse. This leads to a one-way communication passage between atria wherein a right to left shunt can occur. The incidence of PFOs in adults range from 27 to 30%, but less than 6% are found to be greater than a width of 5 mm [4].

Signs and symptoms of PDE can be nonspecific including dyspnea, chest pain, tachycardia, hypoxia, hypotension, electrocardiographic changes, neurological changes, and hemoptysis [2–7]. Diagnostic workup for PDE includes but is not limited to D-dimer levels, duplex ultrasound of the lower extremities, and imaging modalities such as computed tomography scans. Impending PDE can be diagnosed through visualization of entrapped embolus in a PFO or atrial septal defect via chest computed tomography angiography (CTA) or echocardiography [5]. Transthoracic echocardiogram (TTE) and transesophageal echocardiogram (TEE) can both confirm the diagnosis; however, TTE is limited in its ability to differentiate intracardiac thrombus from myxoma [5, 7]. TEE, although more invasive, offers a greater detection rate than TTE and has three times the sensitivity for detecting intracardiac shunts and thrombus [5, 7].

## Case presentation

A 72-year-old obese female with a history of hypertension, hyperlipidemia, gout, and diabetes presented with progressive shortness of breath for 3 days, associated with near syncope, fatigue, and acute on chronic bilateral lower extremity swelling. Labs were notable for a troponin of 0.09 ng/mL and brain natriuretic peptide (BNP) 5250 pg/mL. The patient was tachycardic (100–110 bpm), normotensive, and had $O_2$ saturations ranging from 88 to 95% on 4L nasal cannula while sitting upright. Surgical history was notable for colonoscopies, cataract surgery, and lithotripsy. Her family history was notable for hypertension but negative for hypercoagulable disorders. She had no history of cancer, bleeding/clotting disorders, or recent extended travel. She had no drug use and had quit smoking more than 15 years ago.

CTA demonstrated acute bilateral interlobar PE with right heart strain and thrombus seen within the right atrium and traversing the septum into the left atrium (Fig. 1). A TTE revealed a severely dilated right ventricle (RV), with moderately to severely reduced systolic function, a moderately dilated right atrium (RA), and acute bilateral PEs with right heart strain. Thrombus was seen within the RA, traversing the atrial septum into the left atrium. The left ventricular ejection fraction (LVEF) was noted to be 55–60%, and calculated PA pressures were increased with many PA emboli seen. Emergent embolectomy was planned given the patient's declining respiratory status. ASA Score was IVe.

Standard ASA monitors were applied, a pre-induction arterial line was placed, and large bore venous line was in situ. After careful pre-oxygenation, general anesthesia was induced and the airway secured. There were minimal hemodynamic changes. A 9F central venous catheter (CVC) was placed in the right internal jugular (RIJ) vein. A PA catheter was threaded under TEE guidance into the pulmonary artery (PA). TEE exam revealed an underfilled, D-shaped LV with an LVEF of 60%. The RV was severely dilated, hypokinetic, with a low EF. Thrombus was visualized lodged within the inter-atrial septum, crossing a PFO (Fig. 2A, B). Large clots were also seen in the RA, RV, and right PA (Figs. 2 and 3). Cardiopulmonary bypass (CPB) was initiated after TEE examination confirmed that

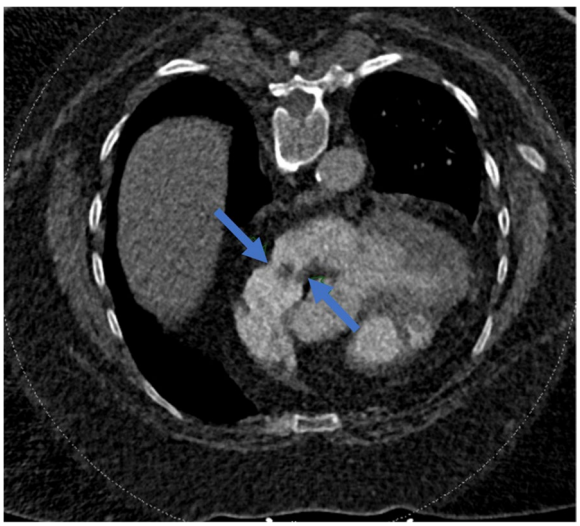
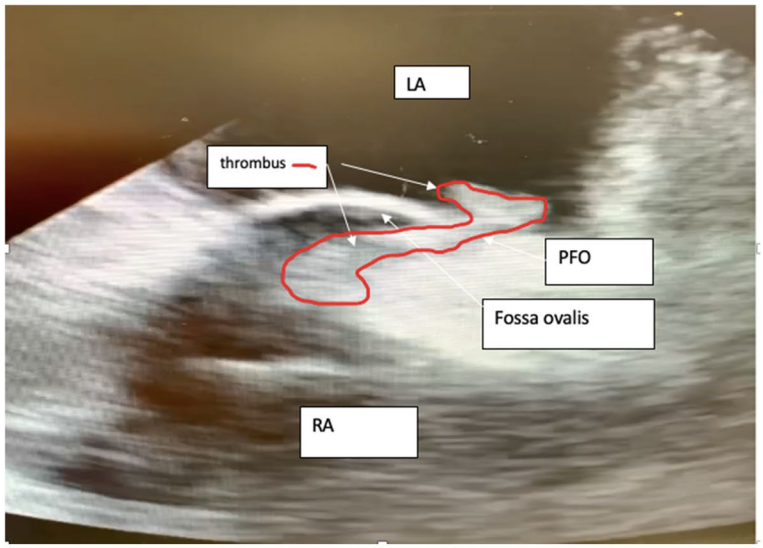


**Fig. 1** Computed tomography angiography demonstrating the thrombus extending from the right atrium into the left atrium, blue arrows




A:


B:

**Fig. 2** **A** Two-dimensional TEE. Close up of foramen ovale and clot traversing PFO. **B** Thrombus in RV

bicaval venous cannulation was safe. Surgical exposure of the RA revealed a single, large type A clot trapped in the PFO (Fig. 3). The clot was manually extracted (Fig. 4) and the PFO examined and closed with a running 4–0 Prolene suture. The clot that was in the PFO measured $14 \times 0.6 \times 0.3$ cm. A small incision was then made in the right PA, and numerous clots were extracted (Fig. 5). The clots extracted from the PA averaged $1.0 \times 0.5 \times 0.3$ cm to $1.5 \times 0.5 \times 0.2$ cm. Separation from CPB was easily achieved, with minimal inotropic support. Post-operatively, the patient remained intubated in the intensive care unit wherein

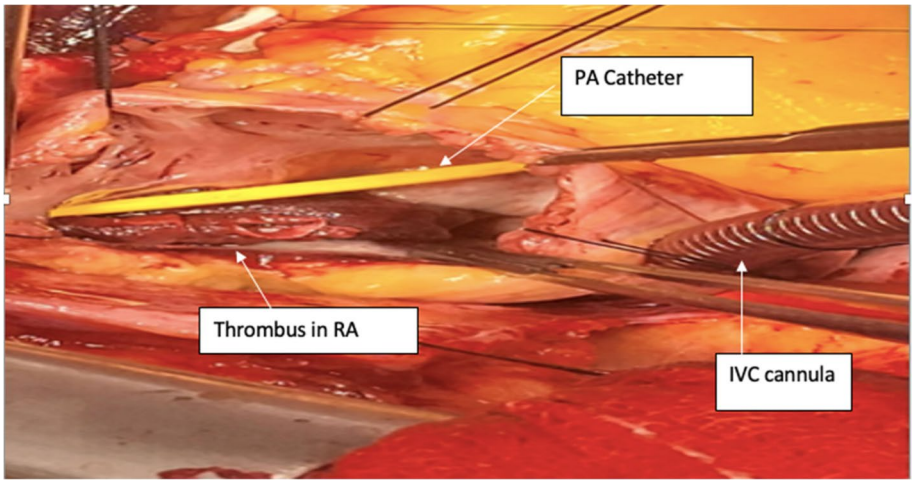



**Fig. 3** Photo illustrating the thrombus in the RA and passing through the PFO

she was extubated day one and completely weaned off inotropic support on day 3. Overall, she tolerated the procedure very well and was eventually discharged to acute rehab due to some deconditioning from being hospitalized.

## Discussion

Prior literature review found that age, shock/hemodynamic collapse, and systemic embolization at presentation were poor prognostic findings [8]. Among survivors, surgery was significantly predicative of survivability [8]. Myers et al. found that nonsurvivors had a higher prevalence of thrombolysis and anticoagulation when compared to the survivor population; however, this finding was not statistically significant which makes treatment choice for paradoxical embolism controversial. Overall, multiple case reports show that surgical thrombectomy show a nonsignificant trend towards improved survival and significantly reduced systemic embolism and composite of mortality and systemic embolism when compared to anticoagulation alone. Given the rarity, it would be difficult to develop universal treatment guidelines.

Anesthetic management of patients with PDE centers around the avoidance of clot migration and arterial embolization of the trapped thrombus. Line placement and cannula placement can be aided with the use of real-time TEE guidance. In addition, TEE is crucial for ensuring proper treatment and complete repair.

CVC and PA line placement in these patients can be tricky. In this case, femoral access was avoided due to the risk of dislocating additional lower extremity thrombi. TEE was used in guiding CVC and PA catheter placement. With the TEE, we were able to visualize the location of the guidewire and catheter while simultaneously viewing the thrombi. The decision to place a PA catheter should be always be weighed against the risk of further clot migration [5]. Alternatively, a PA catheter can be placed into the introducer before CPB and then floated into the PA after separation from CPB [5]. In this case, we placed the PA catheter in the pulmonary artery under TEE visualization, prior to CPB. After initiation of CPB, the catheter was further advanced by the surgeon, while the PA was open for embolectomy.

Cannulation for CPB is also aided with TEE guidance. Bicaval cannulation was preferred for access to the RA, but placement of the inferior vena cava (IVC) cannula, in particular, increased the risk of further thrombus dislodgement and/or embolization. No clots were seen in either the superior vena cava (SVC) or IVC on TEE, leading to safe cannulation. Successful bicaval cannulation avoided femoral and subclavian venous cannulation, and the use of circulatory arrest was minimizing potential morbidity.

TEE is the best way to diagnose and ensure complete treatment of PDE. It is the gold standard for detection of PFOs with a sensitivity of 100% and a specificity of 92% [1]. PFOs are best visualized in the midesophageal four-chamber view or in the bicaval view. PFO confirmation can occur by doing a bubble study. TEE visualization of microbubbles injected venously crossing the interatrial septum and going from the RA to LA confirms the diagnosis. In this case, intraoperative TEE was used to confirm the continued presence of thrombus in the PFO and rule out the presence of other shunts. TEE also confirmed complete closure of the PFO.

Different TEE views were used to locate this patient's numerous thrombi. Thrombi in the RA is best visualized in the mid-esophageal four-chamber and/or bicaval views

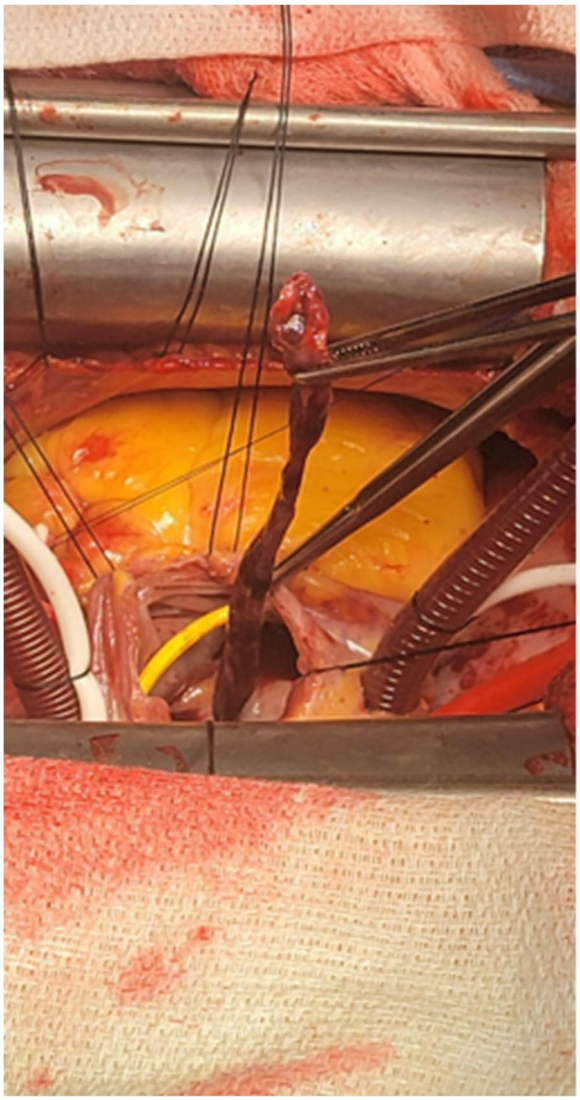


**Fig. 4** Extraction of the thrombus


**Fig. 5** Clot burden. A 13.7-cm clot was retrieved from the PFO (left), and several smaller clots were retrieved from the RPA (right)

between 0° and 90°. Thrombus in the right ventricle RV may best be seen in a midesophageal four-chamber view or in a transgastric view between 80° and 110° [4]. The LA and LA appendage (LAA) can be assessed for thrombi in a midesophageal view between 0° and 150°. TEE sensitivity for LA and LAA thrombi detection in this view is 81% and 98% respectively, and the specificity is 98% and 100% respectively [4].

## Conclusions

TEE plays an important role in the diagnosis and management of paradoxical PE. It can detect right and left heart thrombi and intracardiac shunts, can help in the successful closure of intracardiac shunts, and can impact intraoperative surgical decision making. In addition, evaluation of ventricular function by TEE can help guide management of support required in the pre- and post-CPB periods.

### Abbreviations

BNP: Brain natriuretic peptide; CPB: Cardiopulmonary bypass; CTA: Chest computed tomography angiography; CVC: Central venous catheter; IVC: Inferior vena cava; LA: Left atria; LAA: Left atrial appendage; LVEF: Left ventricular ejection fraction; PA: Pulmonary artery; PE: Pulmonary embolus; PDE: Paradoxical embolism; PFO: Patent foramen ovale; RA: Right atrium; RIJ: Right Internal Jugular; RV: Right ventricle; SVC: Superior vena cava; TEE: Transesophageal echocardiogram; TTE: Transthoracic echocardiogram.

### Acknowledgements

None.

### Authors' contributions

JD, JZ, and GP participated in patient care as well as in the writing and editing of this report. All authors read and approved this case report.

### Funding

There is no external funding to be declared.

### Availability of data and materials

Not applicable.

## Declarations

### Ethics approval and consent to participate

Not applicable.

**Consent for publication**
Written informed consent was obtained from the patient for publication of this case report and accompanying images.

**Competing interests**
The authors declare that they have no competing interests.

Received: 28 November 2022 Accepted: 15 December 2022
Published online: 27 December 2022

**References**

1. Miriyala V, Awan MU, Faraj K, Nagra B (2016) Traversing boundaries: thrombus in transit with paradoxical embolism. J Community Hosp Intern Med Perspect 6(4):31438. https://doi.org/10.3402/jchimp.v6.31438
2. Tan CN, Fraser AG, Warltier DC (2007) Transesophageal echocardiography and cardiovascular sources of embolism. Anesthesiology 107(2):333–346. https://doi.org/10.1097/01.anes.0000270733.26234.56
3. Otoupalova E, Dalal B, Renard B. (2007) Right heart thrombus in transit: a series of two cases. *Critical Ultrasound Journal*. 9(1). doi:https://doi.org/10.1186/s13089-017-0069-9
4. Jena N, Ibrahim R, Tirunagari D et al (2020) Impending paradoxical embolism traversing three cardiac chambers presenting with stroke and pulmonary embolism. Cureus. https://doi.org/10.7759/cureus.9416
5. Dabaliz A-AM, Arain FD (2020) Impending paradoxical embolism: perioperative management and role of transesophageal echocardiography. Seminars in Cardiothoracic and Vascular Anesthesia 24(4):328–336. https://doi.org/10.1177/1089253220940150
6. Worku B, Gulkarov I, Steele J et al (2014) Paradoxical embolus in transit. The Annalsof Thoracic Surgery 98(2):717–719. https://doi.org/10.1016/j.athoracsur.2013.09.068
7. Meacham RR, Headley AS, Bronze MS et al (1998) Impending paradoxical embolism. Arch Intern Med 158(5):438. https://doi.org/10.1001/archinte.158.5.438
8. Myers, P. O., Bounameaux, H., Panos, A., et al. (2010). Impending paradoxical embolism. Chest, 137(1):167–170. https:doi.org/https://doi.org/10.1378/chest.09-0961

## Publisher's Note