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Case Report

From Missed Diagnosis to Precision Surgery: Landmark Four-Dimensional Transesophageal Echocardiography–Cardiac Computed Tomography Angiography Fusion in a Minute Papillary Fibroelastoma

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Abstract

Papillary fibroelastomas are rare benign cardiac tumors, but can be an important cause of cardioembolic stroke, especially when small and located on left-sided valves, where detection may be limited by conventional echocardiography. We report an 80-year-old man with recurrent ischemic strokes and nondiagnostic standard evaluations, including multiple transthoracic and transesophageal echocardiograms, in whom electrocardiographically synchronized cardiac computed tomography angiography (CTA) identified a subtle 2-mm protrusion arising from the noncoronary cusp of the aortic valve. Guided by CT localization, repeat three-dimensional transesophageal echocardiography confirmed the lesion, and intraoperative four-dimensional CT–Transesophageal echocardiography (TEE) fusion imaging was used for precise leaflet localization and surgical guidance. Surgical pathology confirmed papillary fibroelastoma, and the patient has remained free of recurrent cerebrovascular events following excision. This case highlights the added diagnostic and procedural value of multimodal cardiac imaging, expanding the role of cardiac CT and CT–TEE fusion beyond structural interventions to the assessment and management of embolic stroke caused by small valvular tumors.

Keywords: echocardiography–cardiac cta fusion; papillary fibroelastoma; aortic valve tumor; multimodality cardiac imaging; stroke; cerebrovascular accident; transient ischemic attack

Introduction

Primary cardiac tumors are rare. Papillary fibroelastoma (PFE) is the second most common primary cardiac tumor. Despite being benign, it is a significant cause of embolic stroke. PFEs tend to affect the left-sided valves—especially the aortic and mitral valves—where their frond-like, highly mobile surfaces increase the risk of thrombus formation or tumor fragmentation, leading to systemic embolization. Stroke and transient ischemic attack are among the most common initial signs; large studies estimate cerebrovascular events occur in 6–16% of patients, with recurrent events in up to 24% if the tumor remains untreated (Esteban-Lucía et al., 2021; Neupane et al., 2024; Tamin et al., 2015). In a recent systematic review of 161 cases, 67.8% of patients with PFE had stroke, and 32.3% had TIA, highlighting the strong link between valvular PFE and cardioembolic cerebrovascular disease (Neupane et al., 2024). High-resolution imaging, especially TEE, plays a key role in identifying small, mobile tumors that might be missed on transthoracic echocardiography. Early surgical removal remains the definitive treatment, as it significantly reduces stroke recurrence after resection (Esteban-Lucía et al., 2021). Accordingly, we present a case demonstrating the incremental diagnostic and procedural value of electrocardiographically synchronized cardiac CTA integrated with three-dimensional and intraoperative four-dimensional transesophageal echocardiography for the detection, localization, and surgical guidance of a small aortic valve papillary fibroelastoma causing recurrent embolic stroke.

Case Presentation:

An 80-year-old man with a history of tachy–brady syndrome and previous strokes presented with new-onset left-sided weakness and right facial droop. Over the past month, he had been evaluated at sister hospitals at least five times for similar transient neurologic symptoms.

MRI of the brain showed sparse lacunaar infarcts in the right frontal lobe, while both head and neck CT angiography (CTA) and carotid duplex ultrasound were unremarkable for a vascular cause. Transthoracic echocardiography with agitated-saline bubble study did not reveal a significant intracardiac shunt, and contrast-enhanced transthoracic echocardiography showed no left ventricular thrombus.

Multiple prior 2-dimensional transesophageal echocardiograms (TEEs) also failed to demonstrate thrombus within the left atrial appendage. Despite an unrevealing workup, the patient had been empirically started on direct oral anticoagulant (DOAC) therapy.

On the current presentation, the patient underwent repeat transthoracic echocardiography with bubble study and contrast-enhanced transthoracic echocardiography, neither of which demonstrated an intracardiac shunt or left ventricular thrombus. Electrocardiographically (ECG) synchronized cardiac computed tomography angiography (cCTA) was then performed as the final diagnostic test, supported by recent evidence demonstrating a higher diagnostic yield than echocardiography in the evaluation of acute stroke (Rinkel et al., 2022). cCTA revealed a 2-mm low-density tissue excrescence arising from the noncoronary cusp of the aortic valve (Figure 1) and simultaneously confirmed the absence of intracardiac thrombus or patent foramen ovale. Guided by cCTA localization, a repeat TEE with three-dimensional (3D) multiplanar reconstruction (Figure 2) successfully visualized the lesion. Intraoperative four-dimensional (4D) TEE with CT fusion—an innovative multimodality integration not previously described for this indication—was subsequently used for precise leaflet localization (Figures 3 and 4). Surgical pathology (Figure 5) demonstrated fibrocalcific degenerative changes of the noncoronary cusp and a small papillary fibroelastoma (PFE), which was deemed the most likely source of the patient's recurrent cerebrovascular events.

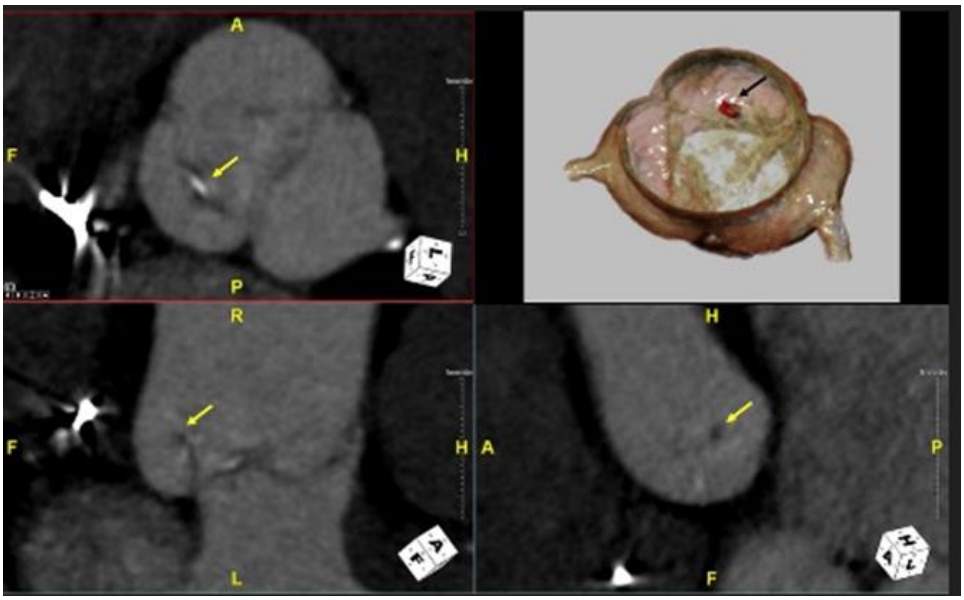
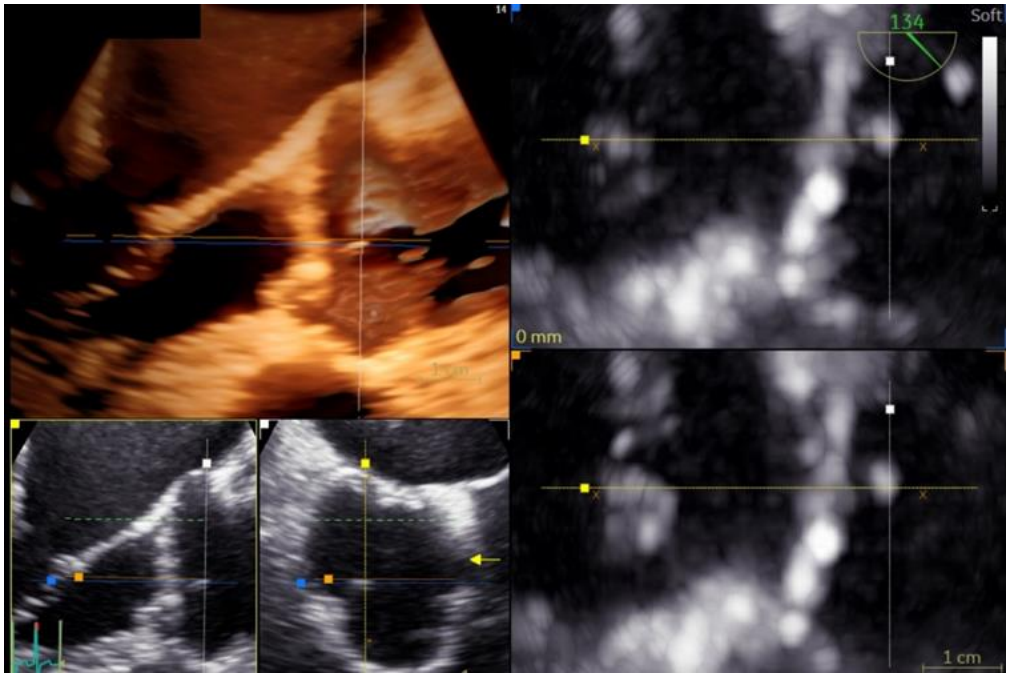


Figure-1



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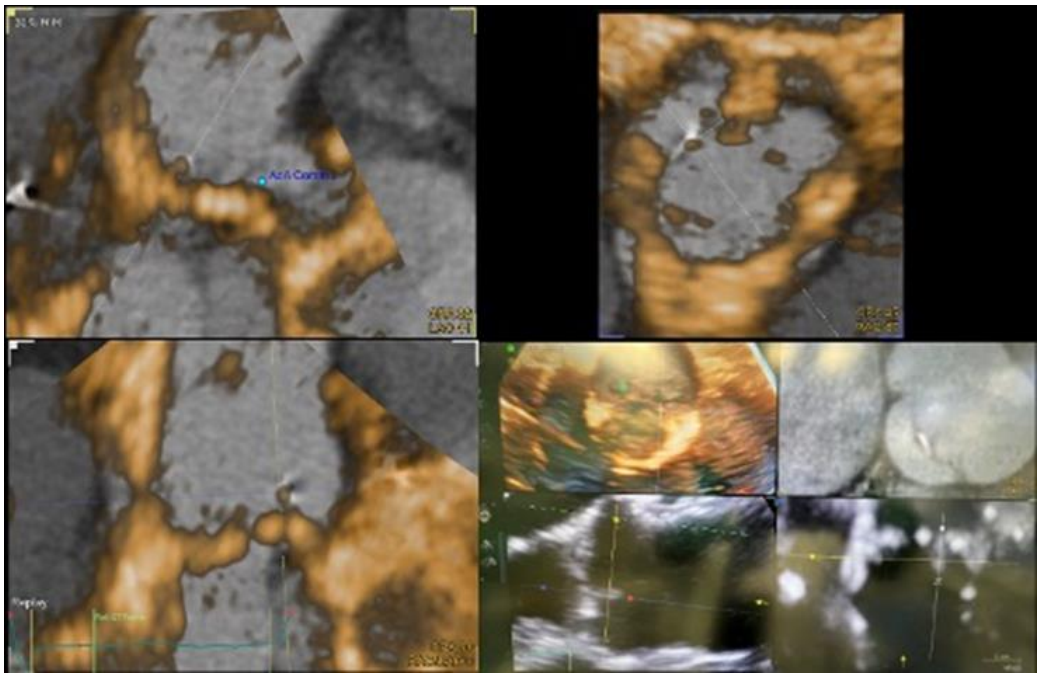

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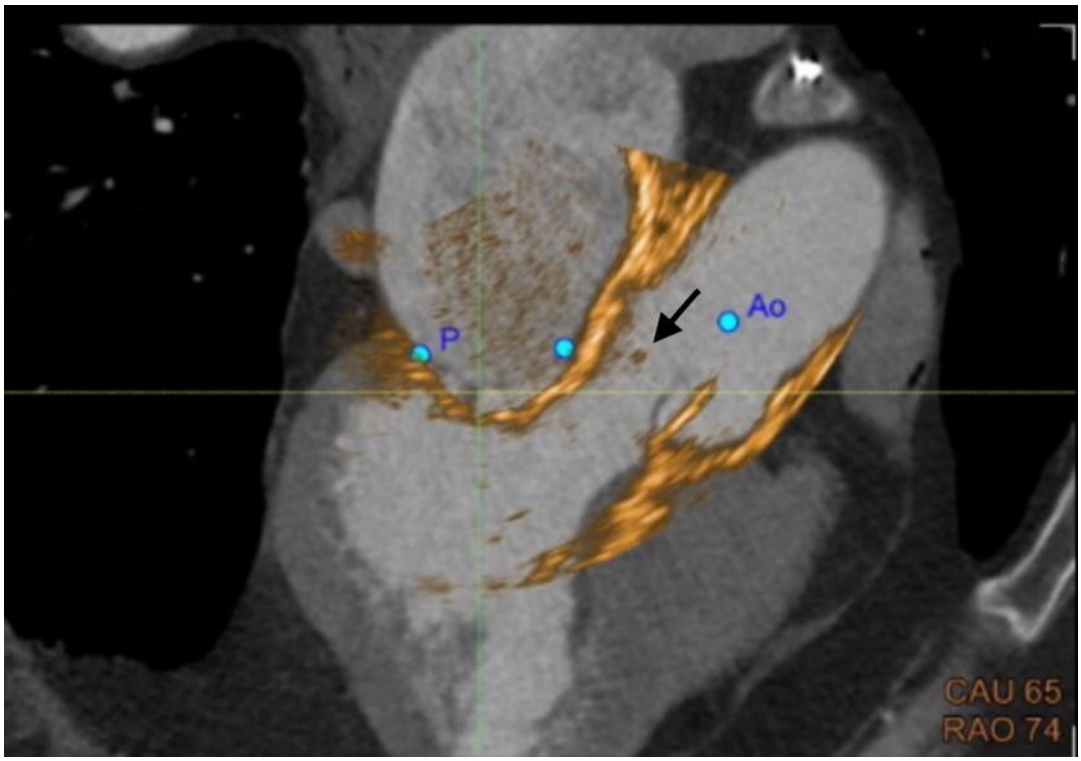

Figure-4

Figure-5

Discussion:

Papillary fibroelastomas, although histologically benign, remain an important and often underrecognized cause of cardioembolic stroke, particularly when small, mobile, and located on left-sided valves. In this case, standard diagnostic evaluation failed to identify an embolic source. Electrocardiographically synchronized cardiac CTA ultimately revealed a subtle 2-mm excrescence on the noncoronary cusp of the aortic valve, which was subsequently confirmed via targeted three-dimensional multiplanar TEE and intraoperative four-dimensional (4D) TEE with CT fusion. Surgical excision demonstrated papillary fibroelastoma on pathology, and the patient has remained stroke-free on follow-up.

This case emphasizes several key concepts. First, very small PFEs may escape detection on standard echocardiography due to the inherent limitations of two-dimensional imaging.

Combining CTA with intraoperative 4D TEE overcame these challenges, allowing accurate localization of the lesion, exclusion of other embolic sources, and seamless guidance during surgical resection. Although multimodality fusion imaging has traditionally been used for structural heart interventions such as valve repair and left atrial appendage occlusion (Fortuni et al., 2020), this case demonstrates its potential usefulness in the evaluation of embolic stroke of undetermined source.

The pathophysiology of cerebrovascular events associated with PFEs remains incompletely understood. Proposed mechanisms include the formation of microthrombi along the tumor surface, which may embolize individually as showers or coalesce into larger thrombi prior to embolization. This theory is supported by a long-standing hypothesis that PFEs may arise from microvascular thrombi that undergo endothelialization and organization over time (Gopaldas et al., 2009). Turbulent flow and endothelial dysfunction at the tumor site may further promote thrombogenesis, consistent with Virchow's triad (Bagot & Arya, 2008). A second mechanism involves direct embolization of friable tumor

fronds. This is supported by reported cases in which histopathologic confirmation of PFE was made from embolic material retrieved during mechanical thrombectomy (Biraschi et al., 2016; Leekoff et al., 2018; Semerano et al., 2021). Notably, cerebrovascular events can occur even in patients receiving anticoagulation therapy. In the systematic review by Neupane et al., cerebrovascular events occurred in 8.1% of patients on anticoagulation and in 34.7% of those on antiplatelet therapy (Neupane et al., 2024), suggesting that tumor fragmentation—not just thrombus formation—is a clinically important mechanism of embolism.

Emerging evidence also highlights the complementary role of cardiac CTA in the acute evaluation of ischemic stroke. In a prospective cohort study, ECG-gated cardiac CT demonstrated a markedly higher diagnostic yield than transthoracic echocardiography for detecting high-risk cardioaortic embolic sources (11.4% vs 4.9%), with cardiac thrombus identified in 7.1% of patients on CT compared with only 0.6% on echocardiography . These findings support the selective use of cardiac CTA—particularly when routine workup is unrevealing or when recurrent cerebrovascular events raise concern for a missed intracardiac or valvular pathology.

Despite growing evidence, the optimal diagnostic strategy for detecting PFE-related embolic sources remains uncertain. Current clinical practice still relies heavily on echocardiography, yet accumulating data suggest that CTA may provide superior sensitivity for small valvular lesions, intracardiac thrombus, and other high-risk features (Esteban-Lucía et al., 2021; Neupane et al., 2024; Tamin et al., 2015). The role of advanced intraoperative fusion imaging is even less defined, limited mostly to structural interventions rather than tumor evaluation. As demonstrated in this case, integrating CTA with 4D TEE fusion may offer unique advantages for preoperative diagnosis and surgical planning, but larger studies are needed to validate its incremental value, determine

appropriate patient selection, and standardize workflow integration within the stroke workup.

Together, this case illustrates how multimodality imaging—including cardiac CTA, 3D multiplanar TEE, and CT–TEE fusion—can expand the diagnostic armamentarium for embolic stroke evaluation, particularly when very small valvular tumors are involved. Early recognition and surgical removal of papillary fibroelastoma provide effective secondary stroke prevention and should be strongly considered when noninvasive imaging reveals even subtle valvular excrescences consistent with PFE.

Conclusion:

This case underscores the diagnostic value of advanced multimodality cardiac imaging in patients with recurrent or cryptogenic embolic stroke when standard evaluation is nondiagnostic.

Electrocardiographically synchronized cardiac CTA, complemented by targeted three-dimensional and intraoperative four-dimensional TEE, enabled definitive identification and precise localization of a 2-mm papillary fibroelastoma that had eluded multiple prior transthoracic and transesophageal echocardiograms. Early surgical excision resulted in complete resolution of cerebrovascular recurrence. Beyond its traditional role in catheter-based structural heart interventions, CT–TEE fusion imaging may offer incremental value for surgical planning and intraoperative guidance in select cases of valvular tumors, highlighting an expanded role for multimodality integration in the management of cardioembolic stroke.

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