Characterization of an Aortic Valve Papillary Fibroelastoma Using Three-Dimensional Transillumination Echocardiography

Bryon A. Gentile, MD, Gerard P. Aurigemma, MD, Timothy P. Fitzgibbons, MD, PhD, and John B. Dickey, MD, *Worcester, Massachusetts*

INTRODUCTION

Echocardiography is integral to the identification and characterization of intracardiac masses. While two-dimensional (2D) echocardiography has been a mainstay in the evaluation of intracardiac masses, three-dimensional (3D) echocardiography offers improved characterization of size, shape, location, and relationship of these masses to surrounding structures.[1] Transillumination (TI) echocardiography is a newer photorealistic rendering of 3D echocardiography utilizing a movable virtual light source to build upon the foundations of 3D echocardiography by improving depth perception and enhancing anatomic details of cardiac pathology including masses, better definition of borders, and attachment to adjacent structures.[2,3] Recently, TI echocardiography has been utilized in the assessment and diagnosis of congenital aortic valve (AV) abnormalities and intracardiac masses, as well as in the real-time guidance of percutaneous mitral valve interventions.[4-7] We report a case in which TI echocardiography was utilized in the diagnosis of an AV papillary fibroelastoma (PFE) in a woman with atrial fibrillation, stroke syndrome, and suspected anticoagulation failure.

CASE PRESENTATION

A 77-year-old woman with a history of hypertension and dyslipidemia was admitted with symptomatic new-onset atrial fibrillation. Vital signs included a pulse of 123 bpm, blood pressure of 135/82 mmHg, and oxygen saturation of 98%. Apart from irregularly irregular heart sounds on auscultation, physical examination was otherwise unremarkable. Transthoracic echocardiography (TTE) demonstrated moderately reduced left ventricular (LV) systolic function (estimated LV ejection fraction 35%) and mild left atrial enlargement. Hemodynamically significant valvular stenosis or regurgitation was not identified. Oral anticoagulation with apixaban was initiated in addition to guideline-directed medical therapy for cardiomyopathy. Following spontaneous conversion to sinus rhythm and treatment with guideline-directed medical therapy, LV systolic function normalized.

VIDEO HIGHLIGHTS

Video 1: Two-dimensional TEE, midesophageal long **(A)** and short **(B)** axis views of the AV and PFE (*white arrows*). Note the shimmering nature of the borders. Three-dimensional TEE, short-axis views of the AV **(C-D)**, demonstrates the irregular borders of the PFE (*red arrows*). *Ao*, Aorta; *LA*, left atrium; *LV*, left ventricle; *PV*, pulmonic valve; *RA*, right atrium.
Video 2: Three-dimensional TEE with TI of the AV, with the virtual light source positioned above **(A-B)** and at the level **(C-D)** of the PFE (*white arrow*). Placing the light source at the level of the PFE enhances the irregularity of the margins using shadowing as contrast (**C**, *yellow arrow*). The independent mobility and irregularity of the PFE are also seen in the shadows below (**D**, *yellow arrows*). *IAS*, Interatrial septum.
Video 3: Comparison of noninvasive TEE 3D **(A)** and 3D TI echocardiography **(C)** to a gross surgical specimen **(B)** of an AV PFE. Of note is improved border definition on 3D TI highlighting irregularity and independent mobility correlating with the elastic fibrils of a PFE (*arrows*).
Video 4: Two-dimensional TTE of the AV at the time of initial presentation (*left*) and 1 year later during an admission for stroke (*right*). Parasternal long-axis views **(A-B)**; parasternal short-axis views **(C-D)**; *arrows* indicate the AV. The AV PFE is not readily visualized, even in retrospect due to suboptimal image quality.

View the video content online at www.cvcasejournal.com.

One year later the patient was readmitted with dysarthria, aphasia, and facial droop. Computed tomography and magnetic resonance imaging of the brain confirmed acute left hemispheric stroke of embolic etiology despite uninterrupted apixaban therapy. Clinically significant atherosclerosis of the ascending aorta, carotid, vertebral, and intracranial arteries was absent. Normal biventricular function without valvular abnormalities was noted on TTE. Hypercoagulable workup was negative. The patient's stroke was felt to be the result of apixaban failure, prompting a transition to rivaroxaban.

The patient was referred for left atrial appendage occlusion as a secondary means of reducing embolic events. Screening 2D and 3D transesophageal echocardiography (TEE) revealed a previously unidentified 9 × 9 mm, independently mobile, pedunculated mass on the aortic aspect of the right coronary leaflet of the AV (Figure 1, Video 1). Transillumination echocardiography provided additional characterization of the mass, highlighting the irregular, frond-like, independently mobile borders, which

From the Division of Cardiovascular Medicine, UMass Chan Medical School, Worcester, Massachusetts.

Keywords: Papillary fibroelastoma, Intracardiac mass, TEE, Transillumination echocardiography, DOAC failure

Correspondence: Bryon A. Gentile, MD, Division of Cardiovascular Medicine, UMass Chan Medical School, 55 Lake Avenue North, Worcester, MA 01655 (E-mail: *bryon.gentile@umassmemorial.org*).

2468-6441
https://doi.org/10.1016/j.case.2024.04.006

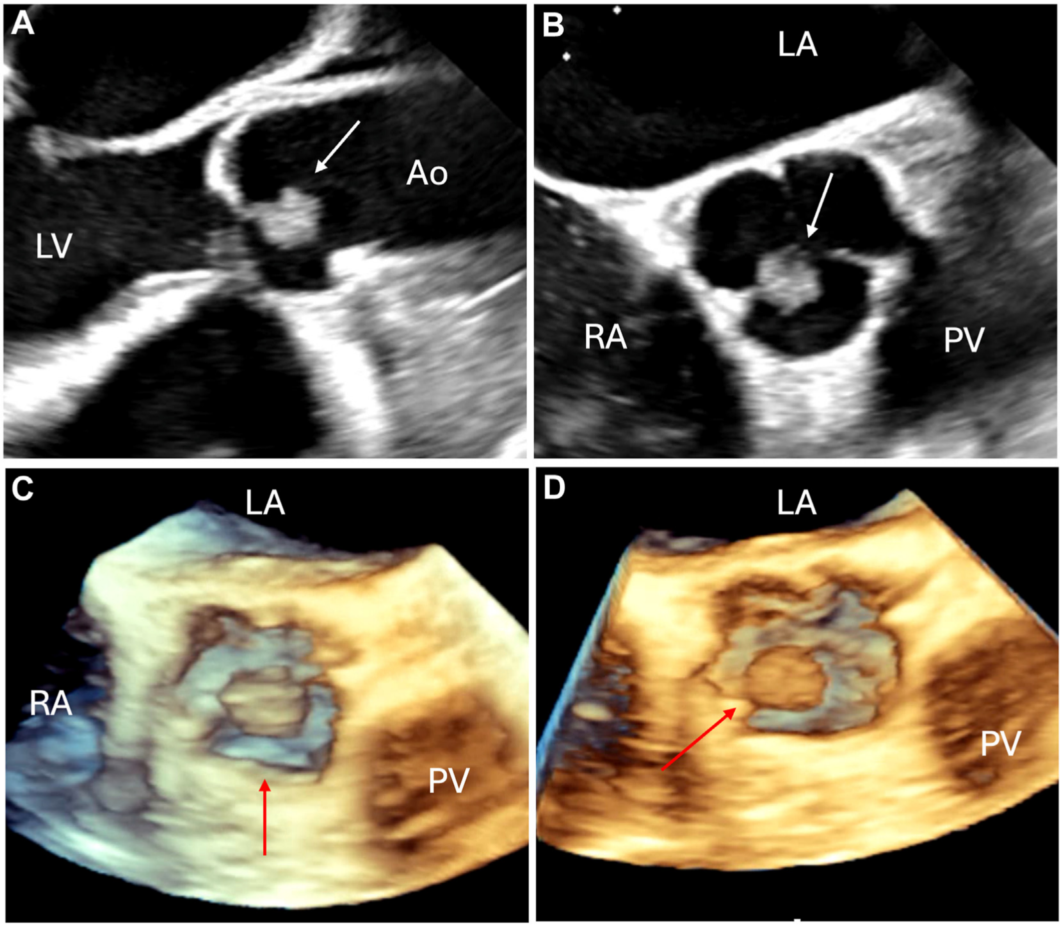

Figure 1 Two-dimensional TEE of the AV from the midesophageal long **(A)** and short-axis **(B)** diastolic views demonstrates a PFE (*arrows*) on the right coronary leaflet of the AV. Three-dimensional TEE of the AV in short-axis diastolic views at slightly different frames and angles **(C-D)** demonstrates the irregular borders of the PFE (*arrows*). *Ao*, Aorta; *LA*, left atrium; *LV*, left ventricle; *PV*, pulmonic valve; *RA*, right atrium.

shimmered with movement (Figure 2, Video 2) suspicious for PFE. The atrial septum was intact without defect or patent foramen ovale.

Valve-sparing surgical excision was performed. Gross pathological and histological specimens confirmed the mass to be a PFE (Figure 3). Postoperative course was uneventful; anticoagulation was continued. One year later, the patient has not had recurrent embolic events.

DISCUSSION

Cardiac PFEs are the second most common intracardiac and most common valvular tumor encountered clinically.[8] With improvements in the diagnostic quality of echocardiography, more recent studies suggest PFEs may be the most common intracardiac tumor.[9] Papillary fibroelastomas are benign, pedunculated, avascular, endothelial masses with variable degrees of elastic fibrils emanating from a central hyaline stroma, yielding a classic "sea anemone"–like appearance when submerged in saline. Although found on all endocardial surfaces, one large series noted the AV to be the most frequently encountered location, with nearly 50% arising from the right coronary leaflet.[10]

Surgical excision is recommended in patients with left-sided PFEs and prior embolic events. More recent nonrandomized data have led some to advocate for a more aggressive surgical approach in asymptomatic patients with left-sided PFE who are deemed good surgical candidates (STS score of <1%) due to an increased risk in embolic events in an unoperated cohort.[9] Surprisingly, these authors did not find a difference in embolic events among unoperated patients treated with oral anticoagulants, dual antiplatelet therapy, or single antiplatelet therapy, although this study was likely underpowered to fully assess the benefits of these therapies.

While both TTE and TEE play a vital role in the diagnosis of PFEs, up to one-third seen on TEE are not seen on TTE, including in this patient (Video 4).[9] Typically described as small (<20 mm), round, pedunculated echodensities emanating from a central stalk, PFEs are independently mobile with a characteristic "stippled" edge that shimmers or vibrates along the tumor-blood interface on 2D echocardiography.[10,11] More recently, 3D echocardiography has been utilized in evaluating the size, mobility, attachment points, and degree of valvular impairment of PFEs to aid in preoperative planning.[1]

Transillumination echocardiography is a 3D-rendering technology that utilizes a movable virtual light source to "illuminate" cardiac structures in a more photorealistic manner. Owing to improved border definition and depth perception, 3D TI echocardiography may be

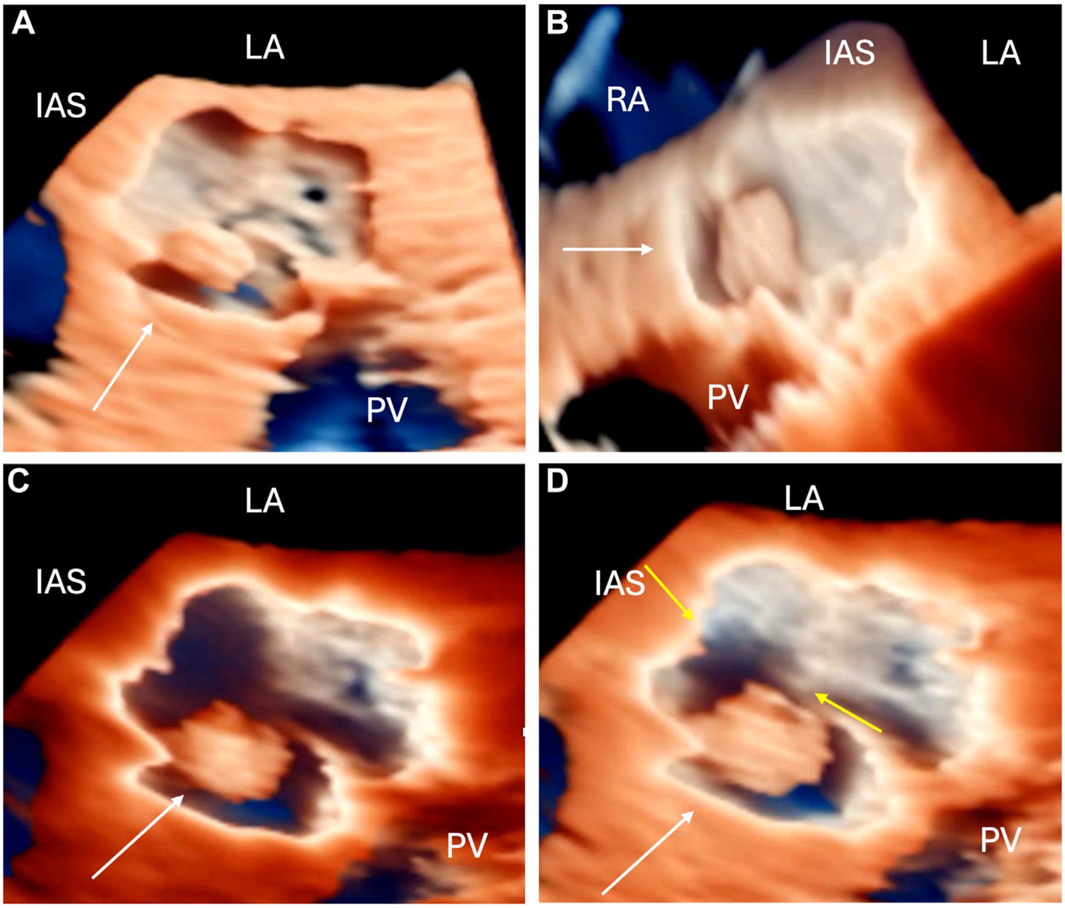

Figure 2 Three-dimensional TEE with TI of the AV in short axis, with the virtual light source positioned above **(A-B)** and at the level **(C-D)** of the PFE (*white arrows*). Placing the light source at the level of the PFE enhances the irregularity of the margins using shadowing as contrast **(C)**. The irregularity of the margins is also visualized in the shadows below the PFE (**D**, *yellow arrows*). *IAS*, Interatrial septum; *LA*, left atrium; *PV*, pulmonic valve; *RA*, right atrium.

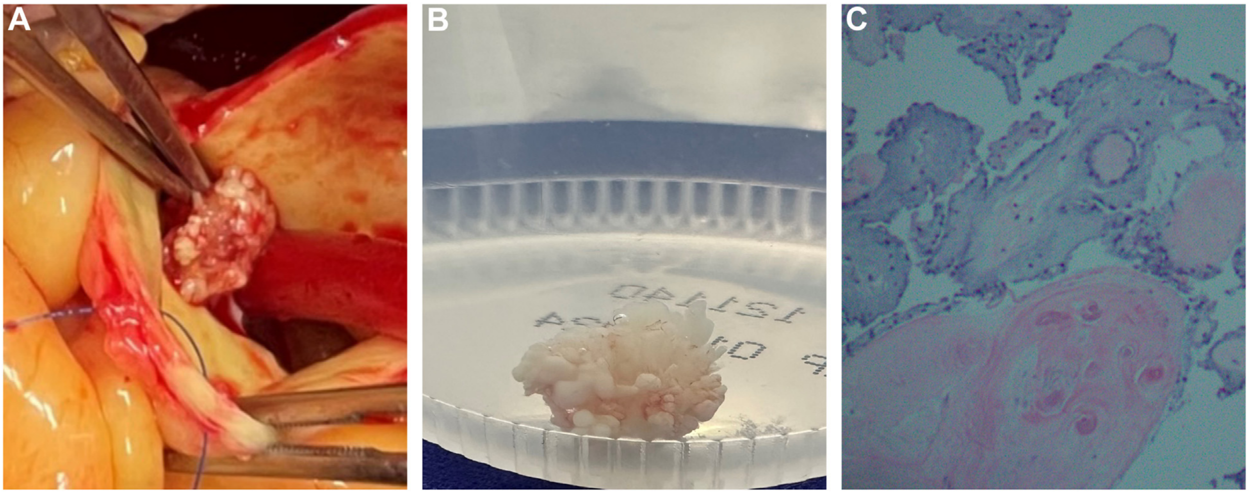

Figure 3 **(A)** Surgical view of an AV PFE in situ. **(B)** Gross pathologic specimen of a PFE submerged in saline with a classic "sea anemone" appearance. **(C)** A 100× histological specimen of the PFE showing multiple, branching fonds of paucicellular, avascular fibroelastic tissue lined by a single layer of endocardium.

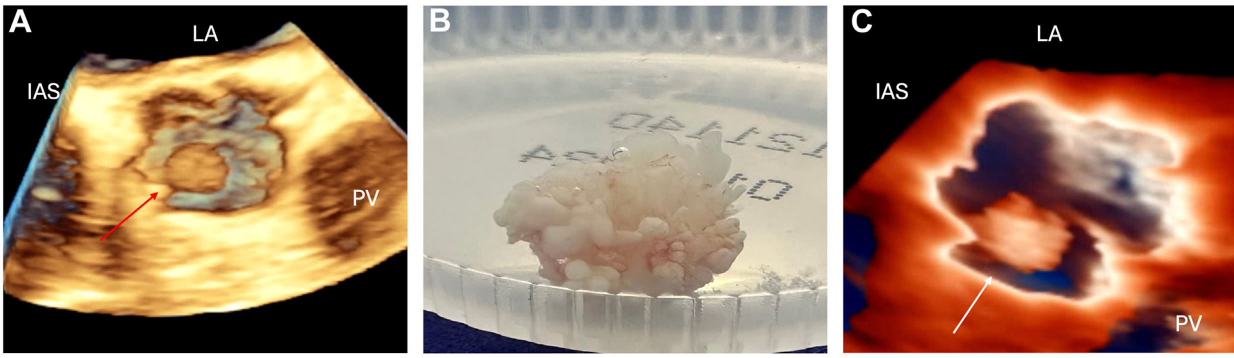

Figure 4 Comparison of noninvasive 3D TEE **(A)** and 3D TI echocardiography **(C)** to a gross surgical specimen **(B)** of an AV PFE (*red and white arrows*). *IAS*, Interatrial septum; *LA*, left atrium; *PV*, pulmonic valve.

an ideal modality in the assessment of intracardiac masses, including PFEs, and may increase the diagnostic confidence of readers in the identification of pathology.[2] Our case illustrates the ability of 3D TI echocardiography to provide enhanced, real-time, characterization of a PFE, most notably highlighting the independent mobility and irregularity of the mass's margin correlating with the elastic fibrils, thereby reproducing its gross pathologic appearance (Figure 4, Video 3). Placing the light source at the level of the mass allowed for the creation of edge shadowing, enhancing the independently mobile and irregular margins of the PFE (Figure 2C, Video 2), which are also seen in the shadows (Figure 2D, Video 2).

In addition to the utility of TI echocardiography, this case highlights the importance of performing a comprehensive TEE prior to structural heart procedures, including left atrial appendage occlusion, to identify additional sources of pathology warranting intervention. Although not specifically excluded in the pivotal PROTECT-AF and PREVAIL trials, or in Food and Drug Administration labeling, this patient's PFE was felt to represent a significant independent risk factor for future embolic events, prompting referral for surgical excision.[12,13] Additionally, the PFE was felt to be the most plausible explanation for the prior embolic event as atrial fibrillation was appropriately treated with an oral anticoagulant and other putative mechanisms for embolic events, including atherosclerosis and patent foramen ovale, were excluded. Had comprehensive imaging not been performed, it is possible that this patient's PFE would have remained undiagnosed.

The importance of avoiding diagnostic anchoring and maintaining a broad differential diagnosis cannot be overstated. Although atrial fibrillation is an important etiology of thromboembolic events, additional cardiac sources of embolism, including intracardiac masses, should be considered in patients with hemispheric strokes, felt to be embolic in origin, particularly when atrial fibrillation has been appropriately managed with an anticoagulant. Indeed, TEE is recommended as an early or supplemental imaging modality for the evaluation of cardiac source of embolism in patients without an identifiable noncardiac source.[14]

CONCLUSION

Transillumination echocardiography builds upon the foundation of traditional 3D echocardiography, enhancing border resolution and depth perception. We present a case where TI echocardiography was utilized to highlight the irregular and independently mobile margins of an intracardiac mass correlating with the elastic fibrils of what was later confirmed to be a PFE. Further research is needed to determine whether TI echocardiography can enhance our noninvasive understanding and identification of intracardiac masses.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

CONSENT STATEMENT

The authors declare that since this was a non-interventional, retrospective, observational study utilizing de-identified data, informed consent was not required from the patient under an IRB exemption status.

FUNDING STATEMENT

The authors declare that this report did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DISCLOSURE STATEMENT

The authors report no conflict of interest.

ACKNOWLEDGMENTS

We thank Dr. Jennifer Walker, Professor of Surgery, UMass Chan Medical School, for photographs of gross pathologic specimens.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2024.04.006.

REFERENCES

1. Zaragoza-Macias E, Chen MA, Gill EA. Real time three-dimensional echocardiography evaluation of intracardiac masses. Echocardiography 2012;29:207-19.
2. Genovese D, Addetia K, Kebed K, et al. First clinical experience with 3-dimensional echocardiographic transillumination rendering. JACC Cardiovasc Imaging 2019;12:1868-71.
3. Italiano G, Fusini L, Mantegazza V, et al. Novelties in 3D transthoracic echocardiography. J Clin Med 2021;10:408.
4. Kendall MR, Chacon M, Janardhanan R. Incidental quadricuspid aortic valve demonstrated by transillumination on three-dimensional transesophageal echocardiography. CASE (Phila) 2023;7:113-5.
5. Martinez-Dominguez P, Luna-Alcala S, Guerra EC, et al. Use of transillumination echocardiography in the assessment and diagnosis of bicuspid aortic valve. Echocardiography 2024;41:e15739.
6. Barreiro-Perez M, Cruz-González I, Martin-Moreiras J, et al. Transillumination and tissue-transparency photo-realistic echocardiography imaging during percutaneous mitral valve interventions. JACC Cardiovasc Interv 2021;14:919-22.
7. Yamat M, Wali E, Lee L, et al. Multiple intracardiac masses involving 3 chambers of the heart. CASE (Phila) 2022;6:467-70.
8. Gowda RM, Khan IA, Nair CK, et al. Cardiac papillary fibroelastoma: a comprehensive analysis of 725 cases. Am Heart J 2003;146:404-10.
9. Tamin SS, Maleszewski JJ, Scott CG, et al. Prognostic and bioepidemiologic implications of papillary fibroelastomas. J Am Coll Cardiol 2015;65:2420-9.
10. Sun JP, Asher CR, Yang XS, et al. Clinical and echocardiographic characteristics of papillary fibroelastomas: a retrospective and prospective study in 162 patients. Circulation 2001;103:2687-93.
11. Klarich KW, Enriquez-Sarano M, Gura GM, et al. Papillary fibroelastoma: echocardiographic characteristics for diagnosis and pathologic correlation. J Am Coll Cardiol 1997;30:784-90.
12. Reddy VY, Sievert H, Halperin J, et al. Percutaneous left atrial appendage closure vs warfarin for atrial fibrillation: a randomized clinical trial. JAMA 2014;312:1988-98.
13. Holmes DR Jr, Kar S, Price MJ, et al. Prospective randomized evaluation of the Watchman Left Atrial Appendage Closure device in patients with atrial fibrillation versus long-term warfarin therapy: the PREVAIL trial. J Am Coll Cardiol 2014;64:1-12.
14. Saric M, Armour AC, Arnaout MS, et al. Guidelines for the use of echocardiography in the evaluation of a cardiac source of embolism. J Am Soc Echocardiogr 2016;29:1-42.