Timing of Intervention for Left Ventricular Mass in the Setting of Acute Obstructive Coronary Artery Disease

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INTRODUCTION

Selection of the best approach to evaluation and management of an incidentally identified intracardiac mass can be complicated. Thus, it is conceivable that doing so in the context of an acute myocardial infarction in a patient that required 4 drug-eluting stents (DESs) and dual antiplatelet therapy (DAPT) can be even more daunting. This unique case reflects the invaluable role of noninvasive multimodality imaging in the comprehensive diagnosis and characterization of an intracardiac mass, the need for optimization of guidelines regarding early intervention, and the challenge posed by management of a cardiac mass in the setting of concurrent acute coronary thrombosis requiring DAPT.

CASE PRESENTATION

A 62-year-old man with history of hypertension, hyperlipidemia, prediabetes, prostate cancer status post–high-intensity focused ultrasound and androgen deprivation therapy, and obstructive sleep apnea presented to the emergency department with a 5-hour history of chest pain with radiation to the neck and jaw. The patient consumed 4 glasses of wine per week, and they denied any tobacco or recreational drug use. On physical examination, the patient appeared acutely distressed. Their temperature was 97.3 °F, heart rate was 90 bpm, respiratory rate was 16, blood pressure was 176/115 mm Hg, and oxygen saturation was 97% on room air. Cardiac exam was significant for normal heart and lung sounds, with no edema. The electrocardiogram demonstrated normal sinus rhythm with a heart rate of 96 bpm, 1-mm ST segment elevations in leads II, III, and avF, and ST depressions in lead avL (Figure 1).

Laboratory evaluation was significant for troponin I elevated to 0.13 ng/mL (reference, 0.0-0.03), acute kidney injury with creatinine 1.5 mg/dL (reference, 0.7-1.2), blood urea nitrogen 25 mg/dL (reference, 8-20), international normalized ratio 1.03, hemoglobin 17 g/dL (reference, 13.5-18), and platelet count 202 K/μL (reference, 130-450). The chest radiograph showed no cardiopulmonary abnormalities (Figure 2).

The patient received aspirin 324 mg orally and 3 sublingual nitroglycerin 0.4 mg tablets, with symptomatic improvement.

Given the concern for inferior ST elevation myocardial infarction, a heparin bolus was administered, and the patient was brought urgently to the catheterization laboratory. Left heart angiogram demonstrated a totally occluded left circumflex artery with high thrombotic burden and 95% tandem lesions in the mid and distal right coronary artery, with left ventricular end-diastolic pressure of 19 mm Hg.

The patient underwent placement of 4 DESs, to the proximal left circumflex, left posterolateral branch, and mid and distal right coronary arteries, with restoration of thrombolysis in myocardial infarction grade 3 flow in all vessels. The patient was initiated on DAPT with aspirin 81 mg daily and ticagrelor 90 mg twice daily. The patient's home metoprolol tartrate 12.5 mg twice daily, olmesartan-hydrochlorothiazide 40 to 25 mg once daily, and atorvastatin 80 mg once nightly were also resumed. The patient was admitted to the intensive care unit for postprocedural monitoring, where they remained hemodynamically stable.

Two-dimensional transthoracic echocardiogram (TTE) was performed immediately following the procedure to assess for myocardial dysfunction. This study showed a low normal estimated left ventricular ejection fraction of 50% (per Simpson's biplane method), hypokinetic basal inferolateral and midinferolateral wall segments, and mild to moderate mitral valve (MV) regurgitation on color flow Doppler imaging (jet area < 4.0 cm^2). A mobile echogenic mass measuring 1.2 cm $\times$ 1.2 cm attached to the mitral chordal apparatus in the left ventricle (LV) was also incidentally observed (Video 1, Figure 3). Two-dimensional transesophageal echocardiogram (TEE), performed for further characterization of the mass, confirmed the TTE findings (Video 2).

The mass showed lack of perfusion following administration of an ultrasound-enhancing agent. For multiplanar high-resolution delineation of the mass, localization, and assessment of myocardial invasion, cardiovascular magnetic resonance imaging (CMR) was conducted. This study demonstrated thickening of the papillary muscle (Figure 4) that was concerning for adherent mass or asymmetric hypertrophy, although the latter was considered to be less likely given the absence of left ventricular hypertrophy or hypertrophic cardiomyopathy. Following administration of contrast, there was subtle peripheral enhancement without significant internal enhancement. The mass also showed mobility separate from that of the papillary muscle (Videos 3 and 4).

Given the mobility, enhancement, site, and mechanism of attachment for the mass, the differential diagnosis included papillary fibroelastoma, partially ruptured anterior papillary muscle, or myxoma. Extensive discussion was held with the cardiothoracic surgery team regarding how best to approach further evaluation and management of the mass at that time. As the patient was asymptomatic, there was no evidence of cardioembolic disease, and the mass did not appear to be causing dysfunction of the MV chordal apparatus, surgical intervention was deemed unnecessary at that time. The patient was discharged home.

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VIDEO HIGHLIGHTS

Video 1: Zoomed-in two-dimensional TTE, apical 4-chamber view, demonstrating an incidental mobile echogenic mass measuring 0.9 cm × 1.0 cm attached to the mitral chordal apparatus in the LV.

Video 2: Midesophageal, two-dimensional TEE, apical 4-chamber view (0°), demonstrates the bright mobile mass in the LV.

Video 3: Cardiac magnetic resonance imaging, steady-state free precession cine sequence, 4-chamber view, demonstrates that the mass is suspected to be separate from the adjacent papillary muscle.

Video 4: Cardiac magnetic resonance imaging, steady-state free precession cine sequence, short-axis view, demonstrates that the mass is suspected to be separate from the adjacent papillary muscle.

Video 5: Repeat two-dimensional TTE, apical 2-chamber view, revealing an increase in the size of the left ventricular mass to 1.4 cm × 1.4 cm, from 0.9 cm × 1.0 cm 1 year previously.

Video 6: Repeat two-dimensional TTE, apical 4-chamber view after administration of an ultrasound-enhancing agent, demonstrating a mobile hypoechoic left ventricular mass.

Video 7: Midesophageal long-axis view on repeat two-dimensional TEE, transducer angle of 121°, demonstrating an enlarged left ventricular mass with likely attachment to the anterolateral papillary muscle.

Video 8: Three-dimensional TEE, with zoom, volume-rendered display, short-axis orientation from the LV apical perspective, demonstrates the distinct, mobile mass with the suspected attachment to the anterolateral papillary muscle.

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

Subsequently, serial echocardiographic surveillance every 6 months showed stability of the mass, and the patient remained asymptomatic. The patient underwent uncomplicated colonoscopy 1 year following their hospitalization. Ticagrelor was permanently discontinued at that time, as it had been 1 year since the patient's prior percutaneous coronary interventions (PCIs). Additionally, based on the results of the HOST-Exam clinical trial, clopidogrel was substituted for aspirin monotherapy. To control hyperlipidemia more optimally, evolocumab and ezetimibe were also initiated.

The patient remained well until 1 year later, when they presented to the emergency department with 1-hour history of right elbow and right-sided perioral paresthesias, as well as diminished dexterity in their right hand. On physical examination, temperature was 98.5 °F, heart rate was 88 bpm, respiratory rate was 16, blood pressure was 141/94 mm Hg, and oxygen saturation was 97% on room air, with a National Institutes of Health Stroke Scale of 1 due to sensory loss in the right upper extremity. To evaluate for intracranial pathology, computed tomography (CT) of the head was performed, showing acute, likely embolic left punctate infarct, as well as old left parietal and occipital lobe infarcts. Laboratory evaluation, chest radiograph, and electrocardiogram were within normal limits. The patient was resumed on DAPT with aspirin 81 mg daily and clopidogrel 75 mg daily.

To assess for underlying etiology of these cerebrovascular accidents and to ascertain the status of the previously identified LV mass, repeat TTE was conducted. This imaging showed preserved ejection fraction of 60% (per Simpson's biplane method) and interval increase in the size of the mass to 1.4 cm × 1.4 cm, from 0.9 cm × 1.0 cm 1 year previously (Figure 5, Videos 5 and 6).

There was no evidence of intracardiac shunt per intravenous injection of agitated saline contrast, with and without Valsalva maneuver. As the mass was found to have grown on TTE, TEE was performed for further characterization, with real-time two- and three-dimensional echocardiography. This study estimated the size of the mass at 1.8 cm × 1.7 cm, likely associated with the anterolateral papillary muscle, and the interatrial septum appeared aneurysmal without evidence of patent foramen ovale (Figure 6, Videos 7 and 8). Chest CT demonstrated a nodular lesion at the edge of the papillary muscle (Figure 7).

The patient's clopidogrel was discontinued, and a heparin infusion was started. The decision was made to surgically resect the intracardiac mass. Prior to the procedure, to ensure patency of the prior stents and no interval development of obstructive coronary artery disease, the patient underwent left heart catheterization. This angiogram revealed patency of the prior stents and no new obstructive coronary artery disease. Sternotomy was then performed, with excision of a 1.5 × 1.4 × 1.3 cm well-circumscribed opaque tan, soft mass with a minimal amount of attached cardiac muscle. Mitral valve structural chord repair was performed. There was echogenicity in the anterolateral chord, suggestive of intramuscular bleeding, as well as minimal left ventricular outflow obstruction evident on intraoperative TEE, which resolved with fluid resuscitation. Histopathologic examination showed papillary fibroelastoma (Figure 8). A timeline of the patient's clinical presentations and associated imaging studies is shown in Figure 9.

The patient was discharged 5 days following the surgery. At their 4-month follow-up outpatient cardiology, cardiothoracic surgery, and neurology clinic appointments, the patient was stable and asymptomatic.

DISCUSSION

Diagnosis

The first consideration for a newly identified intracardiac mass involves its diagnosis and characterization, which are often definitively achieved using histopathologic examination. However, biopsy with or without excision can be problematic in the setting of recent acute coronary syndrome requiring PCI. In addition to inherent operative risks, the periprocedural need to withhold DAPT may significantly increase the potential for acute stent thrombosis or restenosis.[1] The diagnostic pathway pursued in this patient highlights how patient history and clinical presentation, combined with noninvasive multimodal imaging including TTE and two- and three-dimensional TEE, with or without CMR and CT, can be incredibly helpful in elucidating the identity and nature of an intracardiac mass prior to proceeding with more invasive percutaneous or open surgical biopsy.

The 4 classes of intracardiac mass include tumor, thrombus, vegetation, and structural abnormality. Given this patient's history of malignancy, the earliest concern was greatest for tumor or thrombus. The lack of constitutional symptoms and systemic indicators of infection or inflammation, as well as the position of the mass on the downstream side of the MV, rendered vegetation less likely. There was also

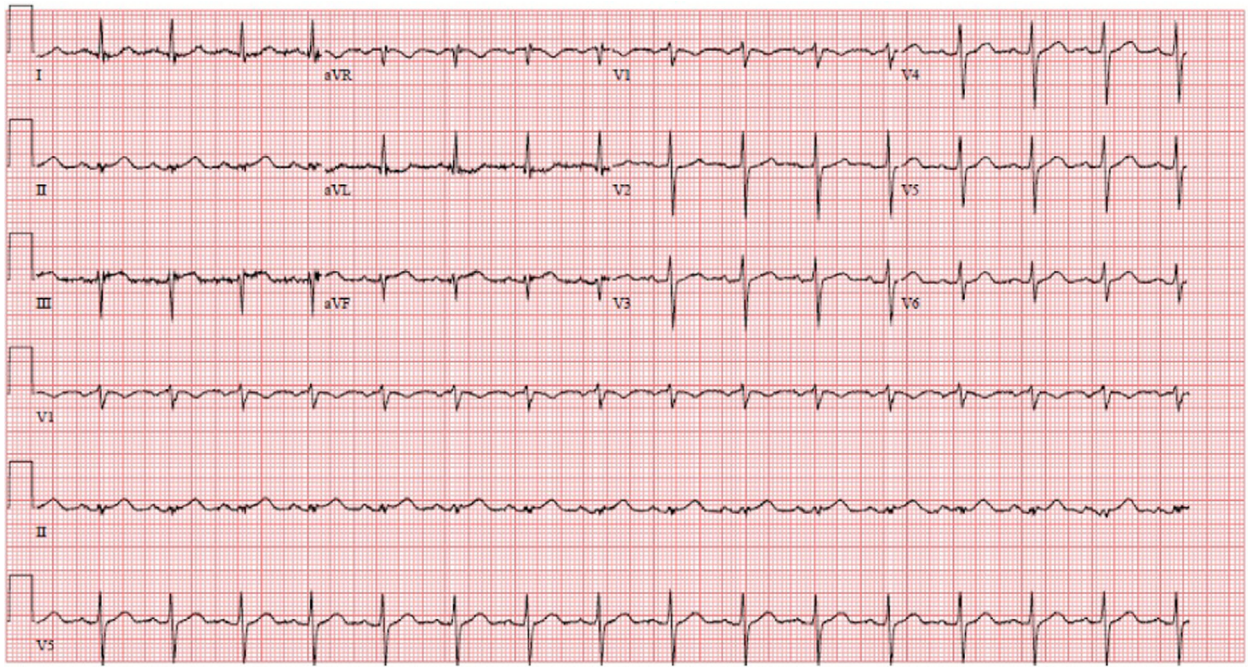

Figure 1 Electrocardiogram showing normal sinus rhythm with a heart rate of 96 bpm, 1-mm ST segment elevations in leads II, III, and avF, and ST depressions in lead avL.

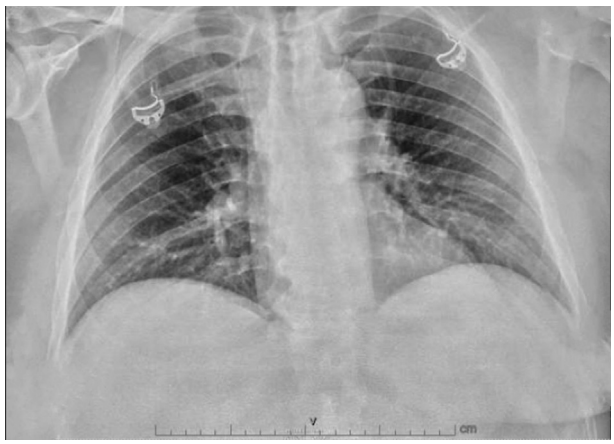

Figure 2 Chest radiograph demonstrating no acute cardiopulmonary abnormalities.

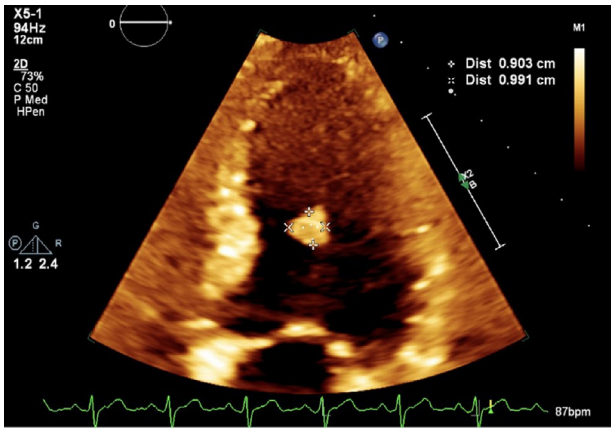

Figure 3 Zoomed-in two-dimensional TTE, apical 4-chamber view, systolic phase, demonstrating incidental mobile echogenic mass measuring 0.9 cm × 1.0 cm attached to the mitral chordal apparatus in the LV.

no rheumatologic disease, imaging characteristics, or involvement of the appropriate ischemic territory to suggest cysts, papillary muscle rupture, or structural changes that could mimic a mass. While there was lack of perfusion of the mass after the administration of ultrasound-enhancing agent, the absence of arrhythmia and apical wall motion abnormality was more consistent with benign tumor than thrombus.

Although secondary metastasis represents the most common form of intracardiac tumor,[2] constitutional symptoms, evidence of paraneoplastic stigmata, and active prostate cancer on CT urography following prior intervention were all lacking in this patient, favoring instead the presence of a primary cardiac tumor (PCT).

As the vast majority of PCTs are benign, and the patient did not exhibit constitutional symptoms or evidence of heart failure, pericardial involvement, or hemodynamic compromise, malignant PCT was thought unlikely. As the patient was an adult, the differential was narrowed to myxoma, lipoma, and papillary fibroelastoma. While cardiac myxoma represents the most common form of benign PCT, they are most often found in the left atrium attached to the fossa ovalis or interatrial septum rather than the ventricle, and approximately 70% occur in women.[3] Lipoma was also a consideration, but it is most often immobile and without a pedicle, in contrast to this patient's mass.

Although rare, papillary fibroelastoma was thought to be highly likely throughout this patient's clinical course, given the presence of a pedicle and its position on the downstream side of the MV, with preserved valvular function.[4] The patient's subsequent presentation with multiple embolic strokes added further support to the diagnosis of

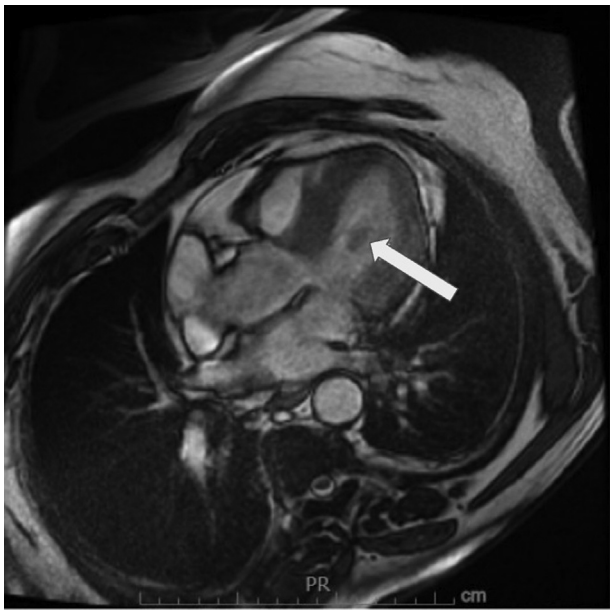

Figure 4 Cardiovascular magnetic resonance imaging was performed, which demonstrated thickening of the papillary muscle (*white arrow*), consistent with adherent mass or asymmetric hypertrophy.

papillary fibroelastoma even prior to histopathologic confirmation of this diagnosis, given the high thromboembolic potential of this type of mass.[5] The key features associated with each differential diagnosis for a left ventricular mass in this patient are as outlined in Table 1.

Hence, the arrival at the most likely diagnosis for this patient's left ventricular mass based on patient history, clinical presentation, and structured multimodal echocardiographic imaging data suggests that a noninvasive approach may be of tremendous diagnostic utility, particularly in patients at high surgical risk or with other factors precluding them from a more invasive strategy. This case further demonstrates how adjunctive use of CMR and CT can provide further structural delineation, localization, and visualization of myocardial invasion, both to refine the diagnosis and to facilitate surgical planning.

Management

Once an intracardiac mass has been identified and characterized, the clinical team must determine the best management approach, including whether to perform surgical excision or monitor with possible medical management. However, as highlighted by the clinical trajectory of this patient, this decision-making process may be complicated by the ambiguity of existing guidelines and requires careful consideration of multiple factors.

Admittedly, the current literature does outline recommendations regarding which classes of intracardiac masses may ultimately require surgical excision.[6] In terms of benign PCTs, complete resection is generally recommended for severely symptomatic lipomas, fibromas,

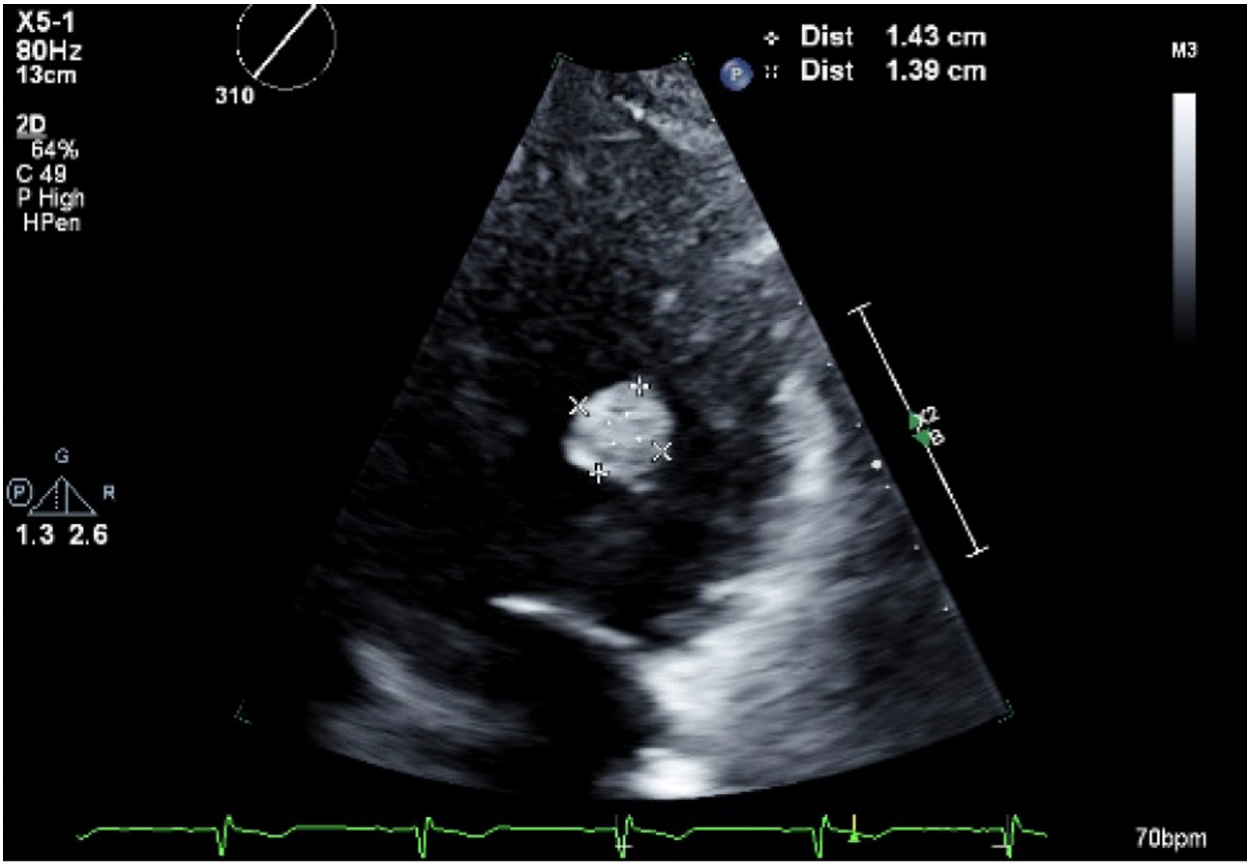

Figure 5 Repeat two-dimensional TTE, apical 2-chamber view, systolic phase, revealing an increase in the size of the left ventricular mass to 1.4 cm × 1.4 cm.

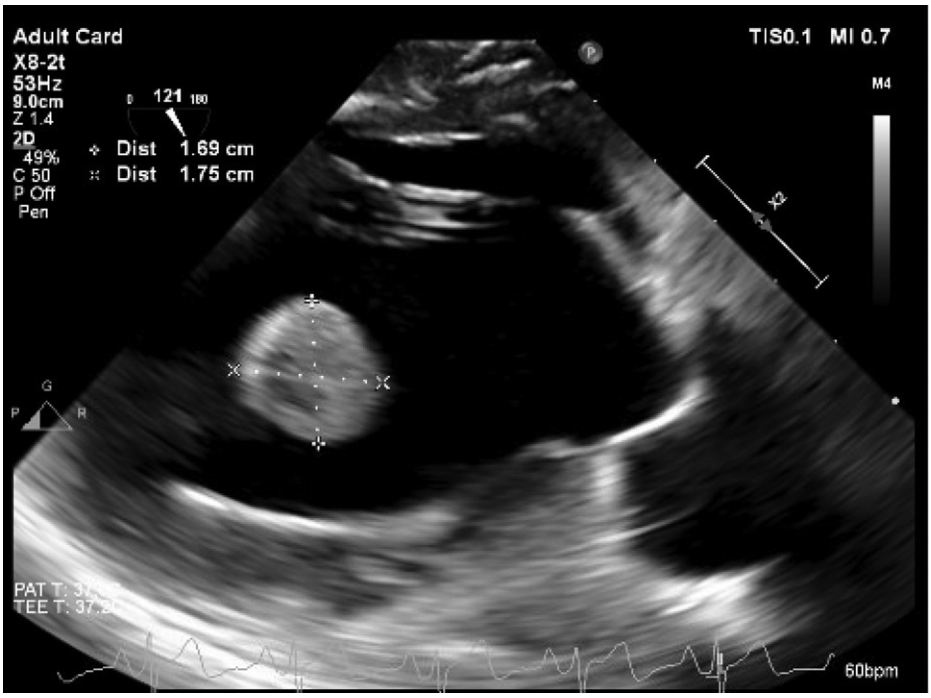

Figure 6 Midesophageal long-axis view on repeat two-dimensional TEE, transducer angle of 121°, systolic phase, showing enlargement of mass to 1.8 cm × 1.7 cm.

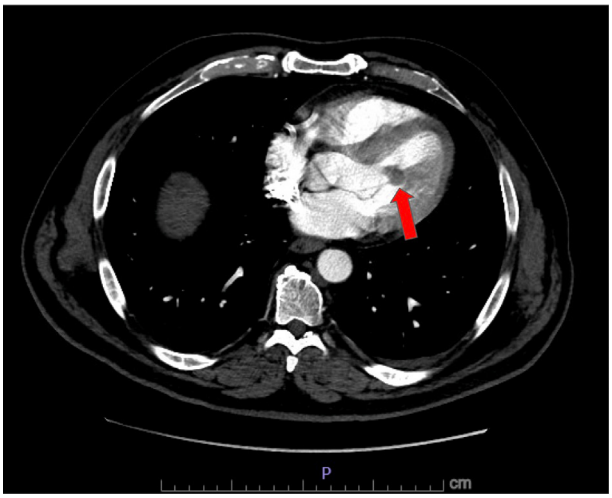

Figure 7 Chest CT with contrast, demonstrating a left ventricular nodular density closely approximating the papillary muscle (*red arrow*).

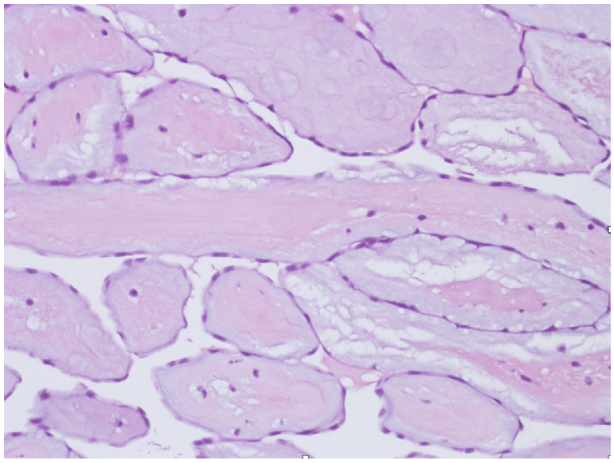

Figure 8 Hematoxylin and eosin stain demonstrating avascular core of hyalinized hypocellular stroma with elastic stroma, lined by layers of endocardial cells, consistent with papillary fibroelastoma.

rhabdomyomas, and cardiac paragangliomas. For malignant PCTs, including angiosarcoma, leiomyosarcoma, rhabdomyosarcoma, osteosarcoma, undifferentiated sarcoma, and mesothelioma, complete surgical resection and/or debulking is recommended whenever possible. There is no role for surgery in primary cardiac lymphoma, and a limited role in the case of metastatic disease.[6] Regarding intracardiac thrombus, a preponderance of studies have validated the use of coumadin and direct oral anticoagulants as treatment options.[7]

Interestingly, however, specific guidelines regarding the criteria for intervention on intracardiac masses with high thromboembolic potential, such as papillary fibroelastomas and myxomas, have not been homogeneously defined. Multiple authors have advocated for immediate surgical excision of a papillary fibroelastoma upon discovery, regardless of its characteristics, to avoid embolic complications and associated morbidity.[8] Another longitudinal study found that papillary fibroelastoma resection is associated with low operative mortality and excellent long-term outcomes, reinforcing a surgical strategy.[9] However, other authors suggest that small (<1 cm), nonmobile, right-sided and/or asymptomatic papillary fibroelastomas can be managed conservatively with careful observation, and surgical intervention may actually be deferred.[10]

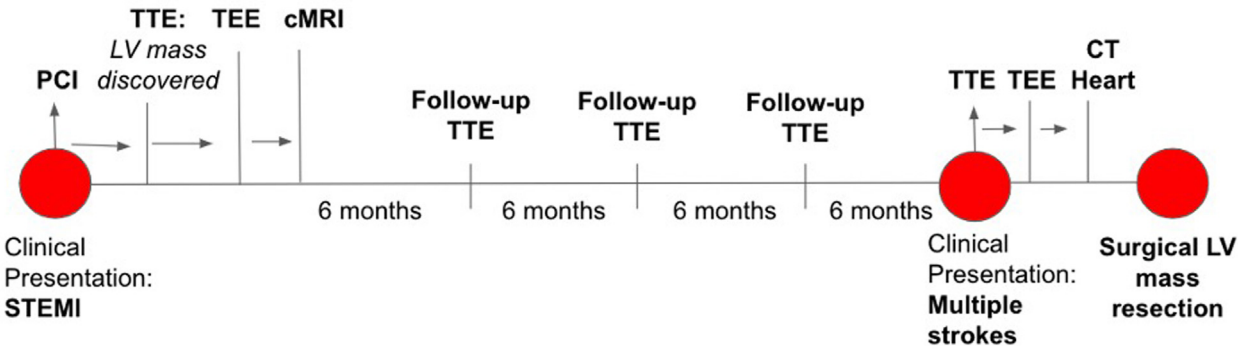

Figure 9 Timeline of the patient's clinical presentations and associated imaging studies. *STEMI*, ST elevation myocardial infarction.

Table 1 Adult left ventricular mass differential and characteristics

Adult left ventricular mass: differential diagnosis	Demographic	Disease associations	Location	Echocardiographic characteristics
Thrombus		Malignancy, hypercoagulable state/systemic thromboembolic disease, arrhythmia	Usually apical	Lack of uptake of enhancing agent
Vegetation		Sepsis, rheumatologic disease	Upstream side of AV valve	Oscillating behavior
Structural Abnormality		Ischemia, anatomic variant, papillary muscle rupture, hypertrophic cardiomyopathy	Variable	Variable
Malignant Tumor		Extracardiac malignancy (if secondary metastasis), paraneoplastic stigmata, hemodynamic instability, heart failure	Interventricular septum, pericardium	Uptake of enhancing agent
Myxoma	Women > men	Carney complex, LAMB, thromboembolic disease	Usually left atrium, attached to fossa ovalis, interatrial septum	Heterogeneous and mobile
Lipoma			Variable	Homogeneous and immobile
Papillary fibroelastoma		Thromboembolic disease	Downstream side of AV valve	Pediculated and mobile

AV, Atrioventricular; *LAMB*, lentigines, atrial myxomas, and blue nevi.

Apart from the conflicting nature of these recommendations, certain criteria upon which the treatment decision is based may not be reliable. In particular, the presence of symptoms is a subjective criterion for intervention, as papillary fibroelastomas are noted to be an incidental finding among one-third of patients, without any associated symptoms.[11] Further, as evidenced by this patient's previously undetected parietal and occipital strokes, embolic events have been found to be clinically silent in approximately 10% to 20% of patients[12] and can therefore be easily missed. Given this frequency of silent embolic events and the high thromboembolic potential of papillary fibroelastomas,[13] and as exemplified by the findings in this case, it may be plausible to consider screening patients for systemic thromboembolism upon initial discovery of an intracardiac mass. However, there are currently no guidelines or studies to support a preemptive head or chest CT angiography to search for stroke or pulmonary embolism in the setting of an intracardiac mass, in the absence of associated symptoms, stigmata on physical examination, or hemodynamic compromise.

It is also important to acknowledge the limitations of serial echocardiographic surveillance of a mass and how this may confound the decision regarding best management strategy. In this patient, the mass was found to have increased from 0.9 cm × 1.0 cm on repeat TTE and was estimated to be even larger on repeat TEE. However, interobserver variability in experience[14] and measurement strategy can affect the accuracy of multiple evaluations of an intracardiac mass over time. Further, it is challenging to compare successive measurements in a mobile mass that migrates in and out of the imaging plane and has no anatomic markers for direct side-by-side comparison. This subjectivity of interpretation and interobserver variability may further call into question the frequency with which echocardiographic surveillance of an intracardiac mass should be performed, as repeat imaging may be prone to fluctuations in measurement of unclear significance.

Hence, change in size and other temporal assessments of a mass may not serve as a reliable sole basis for the need for intervention and should ideally be considered as one of multiple factors in the decision-making process.

In addition to loosely defined overall guidelines, there is a paucity of recommendations on how to alternatively approach intracardiac masses when resection may not be feasible, because of poor surgical candidacy, comorbid disease, or complicated anatomy increasing the risk for vascular compromise following resection. The latter features are represented in this patient, given their fresh coronary artery stents, active DAPT, and involvement of their intracardiac mass with the mitral chordal apparatus. In this patient, the continuation of DAPT beyond 1 year following PCI and/or the addition of supplemental anticoagulation could have been considered in lieu of or as a bridge to surgical resection of the mass. However, while the possibility of anticoagulation has been contemplated, there have been no randomized controlled trials to validate this alternative treatment approach, either in the presence or absence of a comorbid need for DAPT. Further, the use of anticoagulation for stroke due to intracardiac mass has previously been linked with the risk for hemorrhagic transformation of the infarct.[15]

CONCLUSION

The decision regarding how best to evaluate and approach an incidentally identified intracardiac mass is challenging, especially in the setting of comorbid disease. As this case exemplifies, more objective, homogeneously defined guidelines for intervention must be established. Future investigation should also evaluate the role of preemptive screening for thromboembolic disease upon initial detection of an intracardiac mass, as well as alternative management strategies, for those patients in whom surgical management is contraindicated.

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

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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