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Case Report

Intense 18F-FDG uptake in an organizing right atrial thrombus mimicking malignancy

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ABSTRACT

We present a case of an intensely hypermetabolic intracavitary cardiac mass, standardized uptake values max 44.4, that was pathologically proved to be organizing and organized thrombus, negative for tumor. Our patient had previous right atrial mass resection 2 years prior that was pathologically described as either thrombus or infarcted atrial myxoma. She had since been on lifelong controlled anticoagulation; and on routine follow-up imaging, she had recurrent slow growth of a new right atrial mass. During a later hospital admission for chest pain, the mass was evaluated on both transthoracic and transesophageal echo cardiogram, which could not differentiate thrombus vs neoplasm. Cardiac magnetic resonance imaging was equivocal for mass enhancement. The patient underwent fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) evaluation, which revealed intensely hypermetabolic activity within the mass concerning for malignancy, potentially an aggressive tumor. Subsequently, the mass was surgically excised for pathological diagnosis.

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Introduction

A 31-year-old female presents to the emergency department complaining of chest pain. She has a medical history significant for prior right atrial mass resected 2 years prior, which was pathologically diagnosed as a thrombus vs infarcted atrial myxoma. Over the 2 years since then the mass has been noted as recurring and slowly growing. Current admission computed tomography (CT) pulmonary angiography was initially performed and demonstrated chronic appearing pulmonary

emboli, but no acute findings. Given the patient's history, transthoracic and subsequent transesophageal echocardiograms were obtained to evaluate her known intracavitary mass and demonstrated the right atrial mass along the atrial free wall with frond-like extension into the tricuspid valve (Fig. 1). Given that the differential diagnosis for atrial masses includes thrombus or neoplasm, the finding was further evaluated with enhanced cardiac magnetic resonance (CMR) imaging.

CMR imaging demonstrated a hypointense mass occupying the basal posterolateral third of the right atrium on T2

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Fig. 1 – Transesophageal echocardiogram: echogenic mass within the right atrium with protruding “frond-like” extension toward the tricuspid valve.

sequences (Figs. 2 and 3), but not well visualized on non-contrast T1 sequence (Fig. 4). Postgadolinium imaging was equivocal for enhancement during perfusion phase (Figs. 5 and 6), and 12-min delayed images were degraded by respiratory motion (Fig. 7). The noncontrast enhanced CMR examination from 2 years earlier demonstrated the resected right atrial mass as mildly hyperintense on T1 images and heterogeneous on T2 (Figs. 8 and 9, respectively). A precise

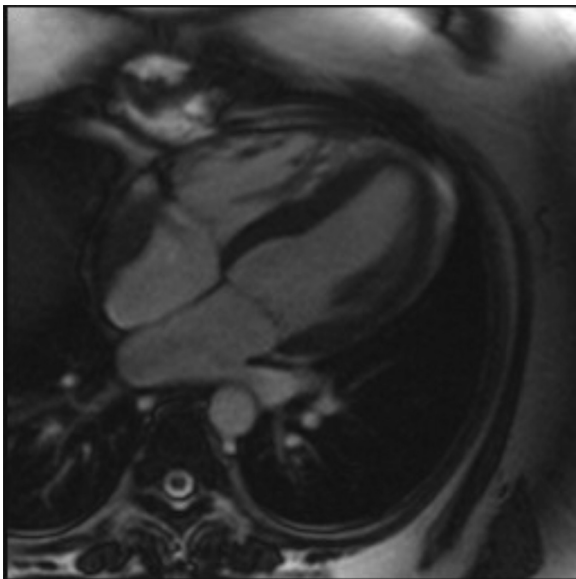


Fig. 2 – Single axial image from T2-steady state free precession cine images shows the hypointense right atrial mass.

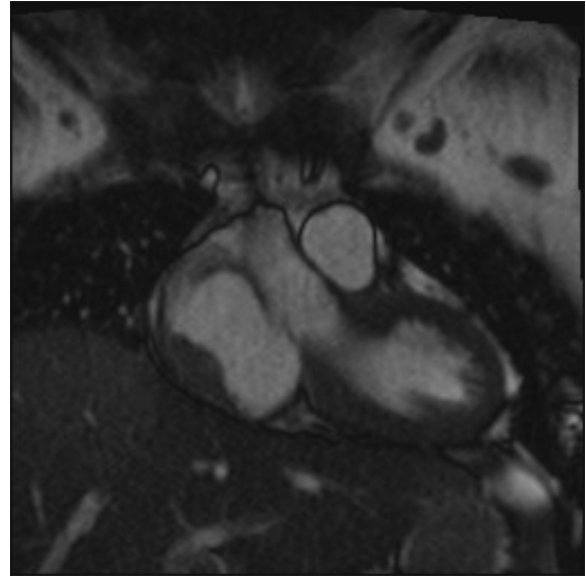


Fig. 3 – Single coronal image from T2-steady state free precession cine images set shows the hypointense right atrial mass.

diagnosis could not be reached by the current CMR, and the differential remained thrombus vs neoplasm.

Fluorodeoxyglucose positron emission tomography/computed tomography (18F-FDG PET/CT) was performed, revealing extremely intense metabolic activity in the mass, with standardized uptake values (SUV) max of 44.4 (Fig. 10). Such intense metabolic activity was felt to be atypical for thrombus, and neoplasm could not be excluded.

Surgical excision of the cardiac mass was performed. Pathologic analysis determined that the mass to be an organizing and organized thrombus, negative for tumor (Fig. 11).

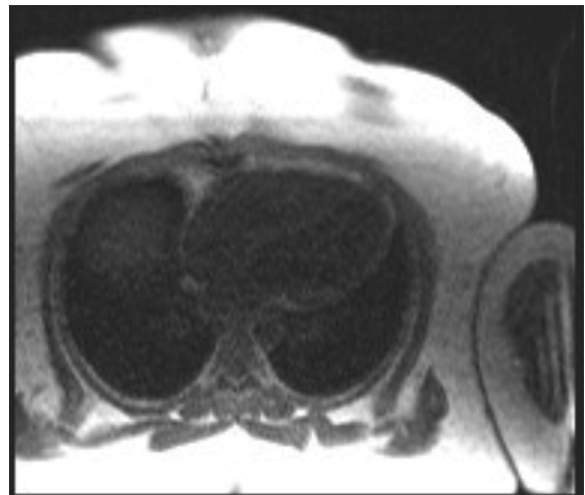


Fig. 4 – Single axial T1 noncontrast gradient image at the level of the right atrial mass demonstrates poor visualization of the mass from background blood pool.

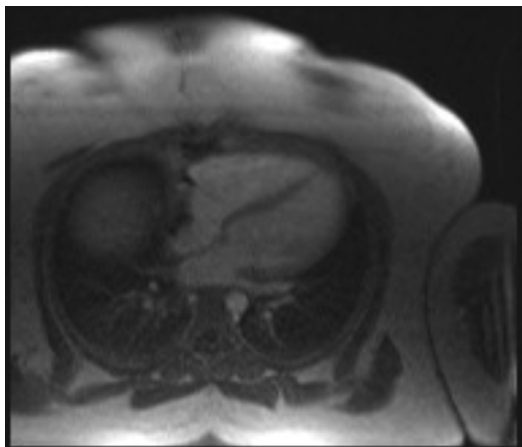


Fig. 5 – Single axial T1 postcontrast gradient perfusion phase image without fat saturation at the level of the right atrial mass demonstrates no appreciable enhancement within the mass.

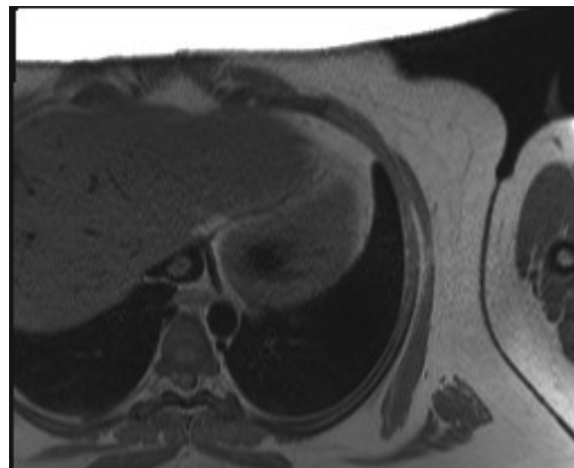


Fig. 8 – Axial T1 postcontrast turbo-spin echo image from patient's cardiac MR performed in 2008, obtained at the level of the previous pathology proven atrial myxoma.

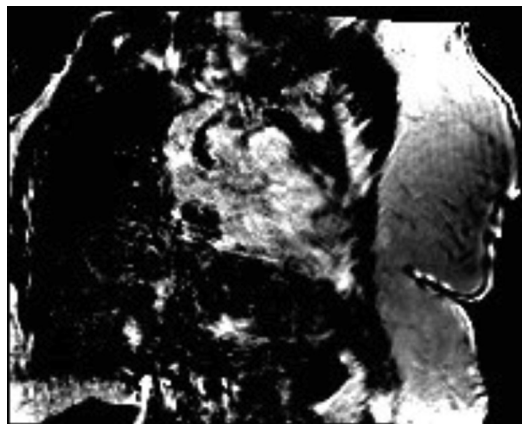


Fig. 6 – Single 2 chamber view T1 phase-sensitive imaging performed during postcontrast gradient perfusion without fat saturation at the level of the right atrial mass demonstrates no appreciable enhancement within the mass.

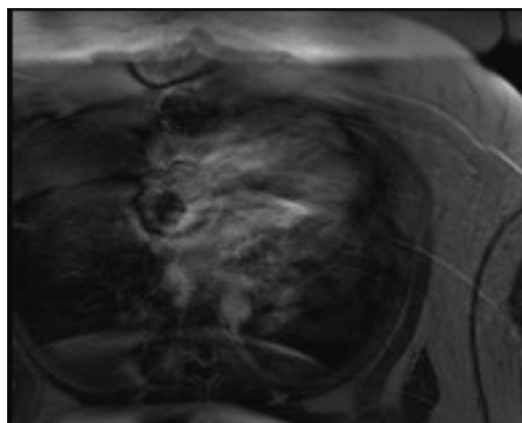


Fig. 7 – Axial 12 minutes delayed postgadolinium inversion recovery, motion degradation rendered assessment for enhancement nondiagnostic.

Discussion

Cardiac tumors are quite rare, reported at autopsy <0.3% with most cardiac tumors representing sequelae of metastatic disease [1]. Of the rare benign primary cardiac tumors, myxoma is the most common. The most common cardiac mass-mimicking tumor is a thrombus [1–3].

CMR imaging demonstrates a high sensitivity and specificity for differentiating thrombus from tumor based on signal characteristics and enhancement patterns [1]. The unenhanced CMR signal intensity of a thrombus will vary based on age of the blood products—acute thrombus tends to be

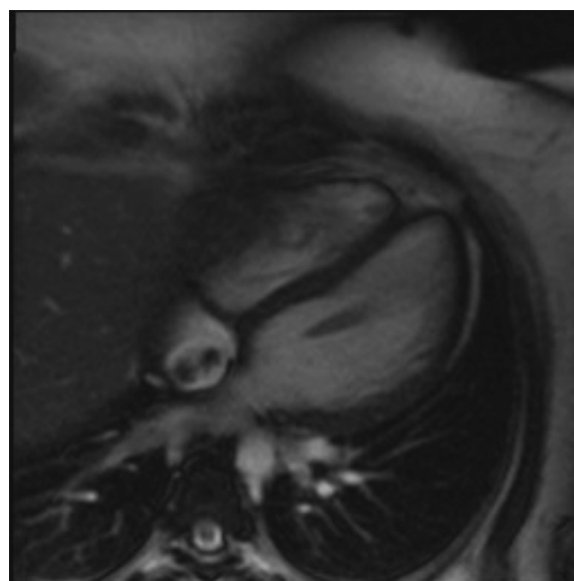


Fig. 9 – Single axial image from T2-steady state free precession from patient's cardiac MR performed in 2008, obtained at the level of the previous pathology proven atrial myxoma. The mass is heterogenous intense.

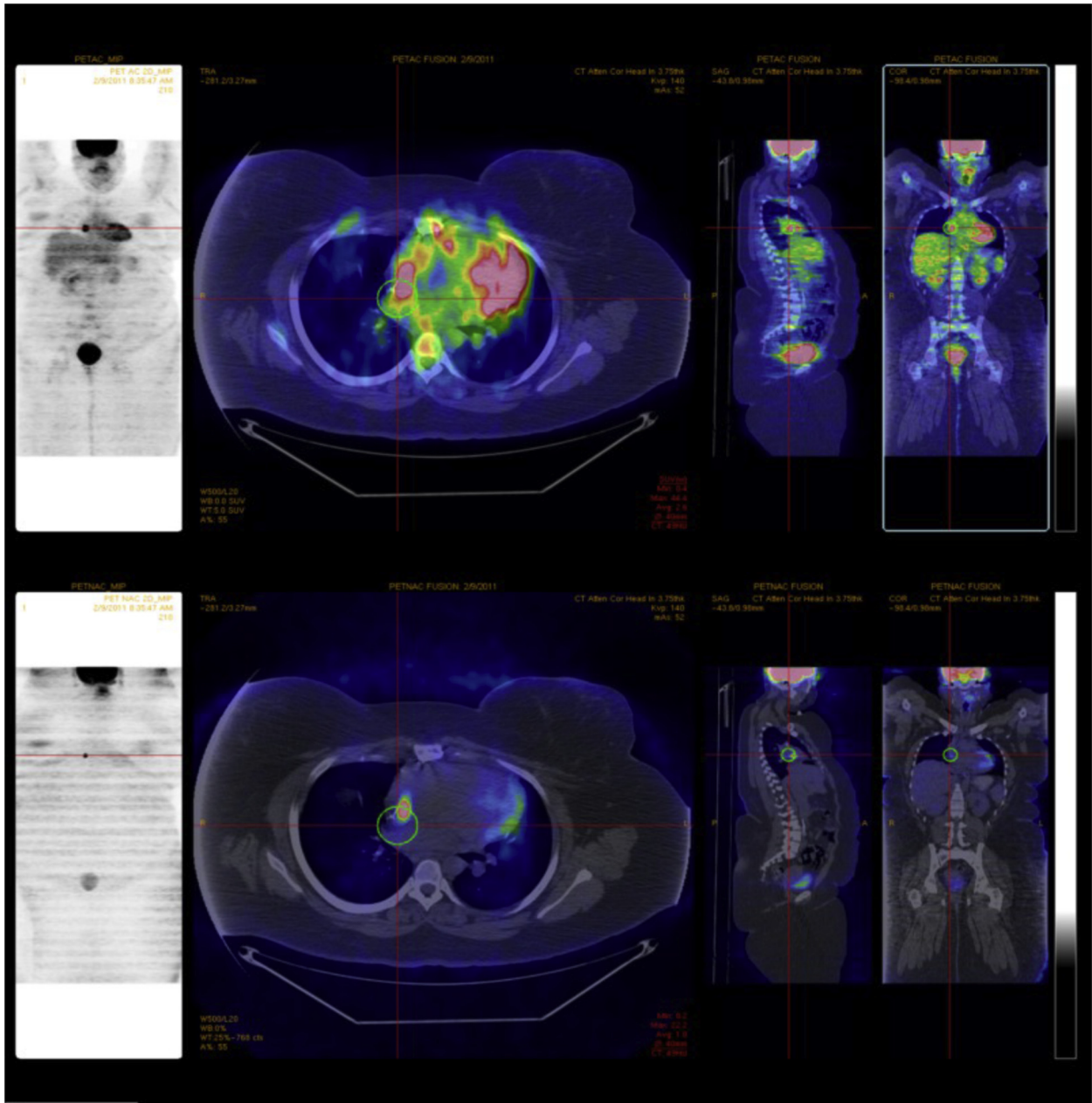


Fig. 10 – 18F-FDG PET/CT demonstrating intense metabolic activity with the mass, standardized uptake values (SUV) max 44.4. 18F-FDG PET/C, fluorodeoxyglucose positron emission tomography/computed tomography.

hyperintense on both T1 and T2; subacute thrombus T1 hyperintense and T2 hypointense related to the paramagnetic effects of methemoglobin; chronic organized thrombus is expected to be hypointense on both T1 and T2 [1]. Use of gadolinium typically reveals an absence of enhancement in thrombus, as opposed to tumor [1]. However, diagnostic dilemmas may arise when thrombi demonstrate enhancement. Although uncommon, enhancement of cardiac thrombi has been previously reported in organized thrombus and should not necessarily be regarded as pathologic [4,5]. In 2016, Tumma et al [6] retrospectively evaluated 46 cardiac masses imaged with CMR and noted enhancement in 4 cardiac thrombi initially considered to represent myxomas based on

enhancement. Of the 30 patients diagnosed as thrombus, 1 patient underwent surgical excision revealing the mass to be a myxoma. Overall, Tumma et al [6] demonstrated a positive predictive value of CMR to diagnose thrombus to be 97% and myxoma 69%.

As a functional imaging modality, 18F-FDG PET may help differentiate cardiac masses as nonmalignant vs malignant based on intensity of metabolic activity. In 2015, Nensa et al [7] prospectively compared the ability of 18F-FDG PET and CMR to differentiate nonmalignant cardiac masses (tumors and thrombi) from malignant cardiac masses in 20 patients with known cardiac masses using an integrated 3T MRI-PET scanner. Sensitivity and specificity for 18F-FDG PET and MR were



Fig. 11 – Gross pathologic specimen excised from the patient's right atrium. Pathologic assessment revealed organizing and organized thrombus, negative for tumor.

calculated independently, and then combined. The mean SUV max for benign tumors and thrombi (8 benign tumors and 3 thrombi) was 2.0 ± 0.9 , and 13.2 ± 6.2 for malignant tumors ($n = 7$). The remaining 2 cases were scar tissue, which when included with the nonmalignant entities increased the average SUV max of nonmalignant entities to 2.3 ± 1.2 . The 3 cases of thrombi demonstrated an SUV max range of 1–2. The 4 cases of myxomas demonstrated SUV max range of 1.2–3.8. A receiver operator characteristic analysis setting of SUV max 5.2 or higher yielded sensitivity of 100% and specificity of 92% in differentiating nonmalignant from malignant cardiac masses [8].

Rahbar et al [8] evaluated the use of 18F-FDG PET/CT in its ability to characterize 24 cardiac tumors as benign vs malignant using histology as the standard for diagnosis (7 were benign, 8 primary cardiac malignancy, and 9 metastases). Mean SUV max in benign cardiac tumors was 2.8 ± 0.6 , malignant primary tumors 8.0 ± 2.1 , and 10.8 ± 4.9 in metastatic tumors. When a cutoff SUV max 3.5 was used, malignancy was determined with a sensitivity of 100% and a specificity of 86%.

18F-FDG PET activity has been well described in other forms of inflammatory or non-neoplastic cardiovascular diseases, including atherosclerosis, pulmonary embolism, and deep venous thrombus [9]. In addition, physiologic myocardial uptake can be quite variable and nonuniform ranging from absent to focally increased with potential pseudomasses, as can be seen because of the papillary muscles and crista

terminalis [10]. Therefore, evaluation of cardiac masses by 18F-FDG PET/CT can be vulnerable to pitfalls.

Previous evaluation regarding the utility in 18F-FDG PET in the setting of acute deep venous thrombosis (DVT) has demonstrated mildly increased metabolic activity associated with acute extremity thrombi, and the decline of metabolic activity over time [11]. Rondina et al [11] prospectively evaluated 12 patients meeting inclusion criteria with unprovoked DVT confirmed with duplex ultrasound within 72 hours of symptom onset. Asymmetric metabolic activity was noted between thrombosed and nonthrombosed contralateral veins. In addition, they noted increased perivascular metabolic activity in those patients imaged within 14 days of DVT symptom onset, proposing a relationship to focally increased inflammation. The SUV max in thrombosed veins was 2.41 compared with nonthrombosed 1.09. Using a best-fit-line analysis, they estimated return of thrombosed veins to physiologic activity levels to be approximately 84–91 days.

Sharma et al [12] conducted a retrospective evaluation differentiating benign thrombus from tumor thrombus using SUV, and reported a sensitivity to differentiate benign thrombus from tumor thrombus of 71.4% and a specificity of 90%. Their retrospective study evaluated 24 patients with known malignancies that simultaneously possessed 18F-FDG avid thromboses in various venous structures including inferior vena cava and portal veins. Thrombosis was classified as benign vs malignant based on structural findings and changes during clinical follow-up (10 benign thrombosis and 14 tumor thrombosis). The average SUV max in benign thrombus was 3.2 and in tumor thrombus 6.0. Sensitivity and specificity were determined using a receiver operator characteristic analysis setting an SUV max of 3.63 [12].

We mentioned earlier that Nensa et al performed CMR assessment of cardiac masses in addition to 18F-FDG PET, and classified CMR cardiac mass features as either benign or malignant [7]. Benign CMR features included intracavitary location, rounded shape, homogenous signal, and blood flow dependent motion. Malignant CMR features included infiltration into adjacent tissue, irregular margins, and signal inhomogeneity. Tumor volumes greater than 23.1 mL correlated with malignancy with a sensitivity of 100% and a specificity of 85%. Hyperintense T2 signal and contrast enhancement both demonstrated 100% sensitivity in detection of malignancy, but had weak specificities—T2 hyperintensity 54% and enhancement 46%. Presence of pericardial effusion was 71% sensitive and 85% specific for cardiac malignancy. When all features of cardiac masses were taken into account, Nensa et al reported malignancy sensitivity of 100% and specificity of 92% [7].

Anatomic imaging modalities, such as echocardiography, CT, and MRI, typically rely on the mass location, attachment point, presence or absence of a stalk, and mobility and infiltration to differentiate between benign and malignant processes [2,3]. Cardiac myxomas are typically located in the left atrium (70%), attached to the interatrial septum (particularly the fossa ovalis) via a narrow stalk, and are mobile with blood flow [1–3]. However, cardiac myxomas can have a variable appearance and occur in any cardiac chamber, with the second most common location being the right atrium [3,4].

Cardiac myxomas can also demonstrate mild metabolic activity as well, as mentioned earlier.

Conclusion

Our case highlights a complimentary approach to evaluate indeterminate cardiac masses through the use of CMR and 18F-FDG PET. Given the indeterminate CMR findings and marked hypermetabolic activity demonstrated in our patient's cardiac thrombus, SUV max 44.4, the patient was appropriately managed surgically to exclude malignancy.

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