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EDITORIAL COMMENT

Solving the Diagnostic Challenge of Right Atrial Mass*

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Cardiac masses are uncommon. However, of all cardiac chambers, a mass in the right atrium creates unique challenges because of the presence of normal anatomical variants that can mimic a tumor. In addition, indwelling catheters and pacemaker leads in the right atrium increase the risk of thrombi or vegetations that can also pose as a tumor.

Chest radiography, transthoracic echocardiography (TTE), and transesophageal echocardiography (TEE) supplement the history and are typically the first-line imaging modalities in the diagnostic evaluation of a right atrial mass. TTE is a readily available and noninvasive imaging modality. However, it is operator dependent, has relatively low spatial resolution, offers limited tissue characterization, and can be technically difficult as a result of poor acoustic windows. Ultrasound-enhancing agents are commonly used to characterize avascular structures and help in differential diagnosis. TEE offers an alternative imaging field, uses higher-frequency ultrasound with improved axial resolution, and can provide detailed anatomical information. It can delineate normal anatomical variants, such as crista terminalis,[1] a prominent eustachian valve, and a Chiari network, and can identify benign conditions, such as lipomatous hypertrophy of the interatrial septum, with greater diagnostic confidence. It is also widely used for diagnosing thrombi and vegetations.

A right atrial mass should appropriately raise concern for a neoplasm, benign or malignant.[2] Myxoma, the most common benign tumor, is typically attached with a stalk near the fossa ovalis. Papillary fibroelastoma is a predominantly valvular lesion and can be attached to the tricuspid valve. Other benign tumors that can be seen in or adjacent to the right atrium include lipomas and cysts. Malignant neoplasms can be metastatic or can grow by extension. Primary malignant tumors of the right atrium are rare (40:1 metastatic to primary ratio) and include angiosarcoma, lymphoma, and pericardial mesothelioma.

Right atrial masses can present a diagnostic challenge, even after careful consideration of the clinical context and the use of first-line imaging modalities. Advanced cardiac imaging offers an invaluable diagnostic tool, and it has been systematically applied in recent studies.

Cardiac magnetic resonance (CMR) plays a pivotal role in the diagnosis of a right atrial mass.[3] CMR offers superior anatomical and contrast resolution, tissue characterization, and ability to assess perfusion. A thoughtful and detailed application of various sequences commonly, but not invariably, allows the differential diagnosis of various intracardiac masses. In 1 study, cine images, T_1-weighted turbo spin echo and T_2-weighted turbo spin echo images, first-pass perfusion, postcontrast inversion time scout, and late gadolinium enhancement sequences were used to diagnose undifferentiated cardiac masses. Morphologic features that were helpful in the differential diagnosis included size, homogeneity, and mobility of the mass. Tissue characterization techniques were highly accurate in differentiating thrombi from tumors. Conversely, CMR had only moderate accuracy in differentiating benign from

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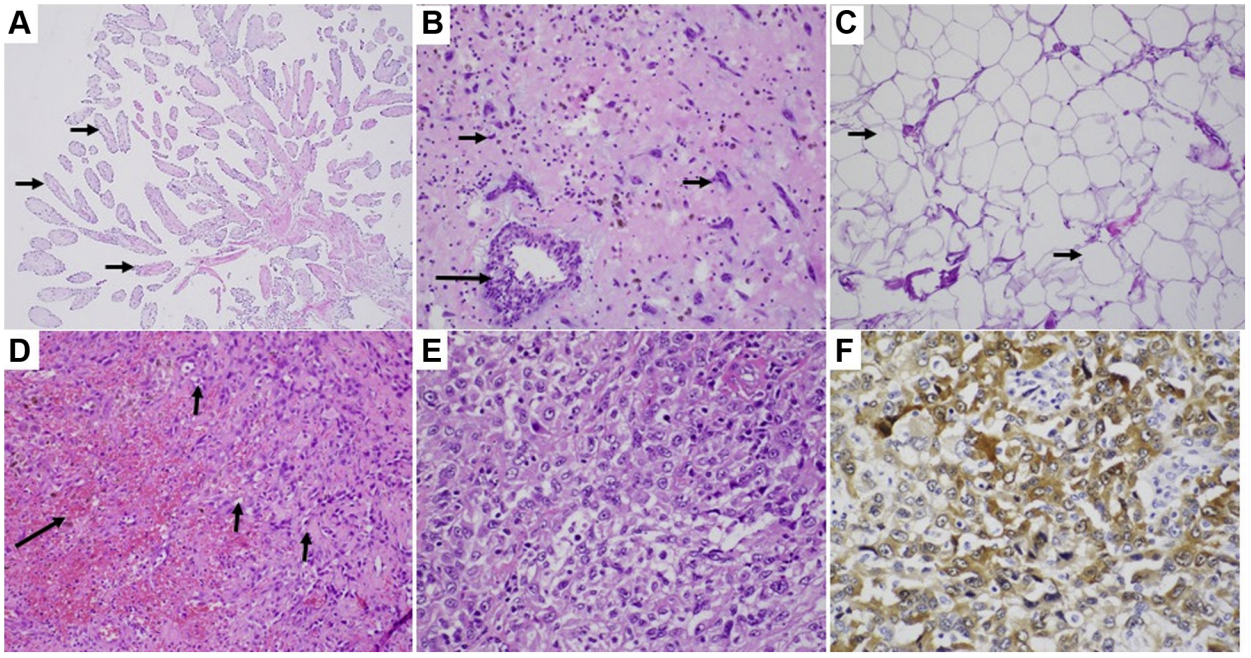
FIGURE 1 Histologic Features of Representative Cardiac Tumors



(A to C) Images of 3 benign cardiac tumors: **(A)** papillary fibroelastoma, **(B)** myxoma, and **(C)** lipoma. **(D to F)** Images of 2 malignant cardiac tumors: **(D)** angiosarcoma and **(E)** and **(F)** pericardial malignant mesothelioma. **(A)** Papillary fibroelastoma is composed of arborizing fronds **(arrows)** that have avascular cores and are lined by a single layer of endothelium. **(B)** Cardiac myxoma is characterized by presence of stellate myxoma cells that are present singly and in clusters **(short arrows)** in a myxoid background. The myxoma cells can form rings around blood vessels **(long arrow). (C)** Lipoma is composed of mature fat cells or adipocytes **(arrows). (D)** Anastomosing poorly formed vascular channels **(short arrows)** lined by malignant endothelial cells and areas of hemorrhage **(long arrow)** are seen in angiosarcoma. **(F)** The pericardial mesothelioma in this case is composed of pleomorphic epithelioid cells. The differential diagnosis of malignant tumors with this morphologic pattern includes metastatic carcinoma, metastatic melanoma, and malignant mesothelioma, epithelioid type. Immunohistochemical stains are performed to differentiate among these entities. This tumor stained positive for cytokeratin, **(F)** calretinin, and WT1, thus supporting the diagnosis of malignant mesothelioma. (**A to E,** Hematoxylin and eosin stain; **F,** immunohistochemical stain for calretinin; original magnifications: **A,** 10×; **B to D,** 20×; **E** and **F,** 40×.)

malignant tumors, even after factoring in first-pass perfusion and late gadolinium enhancement. One also should note that small and mobile masses may not be adequately characterized by CMR. In addition, other obvious limitations can restrict the clinical application of CMR, such as advanced renal disease, older-generation implantable devices, and patient cooperation.

Contrast-enhanced cardiac computed tomography (CT) has the advantage of high spatial resolution, tissue characterization, accurate assessment of perfusion, and ability to detail the surrounding structures. 18-Flurodeoxyglucose (FDG) positron emission tomography (PET), typically integrated with CT or CMR imaging, has emerged as an important modality that demonstrates increased metabolic activity of tumors.[4,5] This is a powerful tool for diagnosis, localization of biopsy sites, and, in case of malignant tumors, treatment response follow-up. In 1 study, cardiac masses detected by echocardiography were further evaluated using both cardiac CT and ^{18}F-FDG PET combined with CT.[6] The study results supported the complementary diagnostic role of both CT and FDG PET characteristics. If ≥5 of 8 concerning CT signs (irregular tumor margins, pericardial effusion, invasion, solid density, diameter >30 mm, calcification, isodense signal, and contrast enhancement) were present, then the mass was most likely a malignant tumor, whereas ≤2 CT signs identified a benign tumor. In patients with 3 to 4 concerning CT signs, an FDG PET abnormality helped to identify malignancy. In another study, FDG uptake intensity was useful in detecting metastases of malignant cardiac tumors.[7] Although diagnostically helpful in many scenarios, FDG uptake, especially mild uptake after a proper dietary regimen, can be seen in a variety of nonmalignant conditions. Focal mild right atrial FDG

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uptake has been reported in the right atrial appendage, in the crista terminalis, and at the site of previous surgery.[8] Atrial myxomas commonly demonstrate mild ^{18}F-FDG uptake despite being benign tumors. Lipomatous hypertrophy of the interatrial septum represents deposition of mature adipose tissue that shows increased FDG uptake resulting from the presence of cells resembling brown fat. Interestingly, cardiac lipomas, which are encapsulated benign, fat-containing tumors, do not typically show intense FDG uptake. Obviously, infected and inflammatory lesions would demonstrate FDG uptake, and these lesions should be suspected on clinical grounds.

In this issue of *JACC: Case Reports,* Takeuchi et al[9] present their case of a 72-year-old woman with a previous history of atrial septal defect closure and tricuspid valve intervention who was evaluated for exertional dyspnea and lower extremity edema. Noncontrast TTE revealed a large right atrial mass causing functional tricuspid valve stenosis and confirmed by TEE. This solid mass was attached to the interatrial septum and tricuspid annulus and extended toward the anterior and posterior leaflets of the tricuspid valve and the aortic root. Advanced cardiac imaging was appropriately performed, including cardiac CT, CMR, and FDG PET. First-pass perfusion and late gadolinium enhancement characteristics of the mass on CMR were not reported, but the mass demonstrated intense FDG uptake on PET imaging. Overall, the imaging findings were concerning for primary cardiac malignancy extending into the surrounding cardiac tissue. Percutaneous cardiac biopsy was performed under intracardiac echocardiography guidance. The pathologic findings were consistent with a very rare condition at the site of previous surgery, phosphoglyceride crystal deposition disease. The mass was not amenable to excision, and the patient was managed conservatively with close monitoring. Fortunately, 12 months after the initial diagnosis, the mass appeared unchanged when imaged by echocardiography.

Although this specific case eventually disclosed a very rare pathologic entity, it highlights the caveats of noninvasive assessment of cardiac masses. The existing armamentarium of noninvasive imaging is broad, and it offers detailed morphologic delineation, tissue characterization, and metabolic activity assessment. Many of the advanced techniques require expertise available only at experienced centers, but they offer a high diagnostic yield in most cases. Even with a full spectrum of available imaging modalities, the correct diagnosis may remain elusive, and only the tissue biopsy eventually provides the answer (**Figures 1A to 1F**).

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