

REVIEW

Cardiac tumors: echo assessment

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Abstract

Cardiac tumors are exceedingly rare (0.001–0.03% in most autopsy series). They can be present anywhere within the heart and can be attached to any surface or be embedded in the myocardium or pericardial space. Signs and symptoms are nonspecific and highly variable related to the localization, size and composition of the cardiac mass. Echocardiography, typically performed for another indication, may be the first imaging modality alerting the clinician to the presence of a cardiac mass. Although echocardiography cannot give the histopathology, certain imaging features and adjunctive tools such as contrast imaging may aid in the differential diagnosis as do the adjunctive clinical data and the following principles: (1) thrombus or vegetations are the most likely etiology, (2) cardiac tumors are mostly secondary and (3) primary cardiac tumors are mostly benign. Although the finding of a cardiac mass on echocardiography may generate confusion, a stepwise approach may serve well practically. Herein, we will review such an approach and the role of echocardiography in the assessment of cardiac masses.

Key Words

- ▶ ventricular mass
- ▶ atrial mass
- ▶ cancer
- ▶ echocardiography

Introduction

Cardiac masses have captured the attention since the beginning of echocardiography. A key reason lies in the fact that the overall prevalence of primary cardiac tumors is exceedingly rare, less than 0.1% in large autopsy series (1, 2). Accordingly, most cardiac tumors are found incidentally during routine cardiac imaging. Most commonly, as widely available and applicable, echocardiography is the imaging technique of choice. It can delineate multiple cardiac structures and characteristics of a mass such as its mobility, attachment and potential hemodynamic consequences. It also allows for serial imaging over time without the need for radiation, iodine or gadolinium contrast agents.

However, echo contrast agents are useful to confirm the presence of an intracardiac mass and to characterize it further by virtue of the extent of contrast enhancement, which is a marker of vascularity (Fig. 1). Accordingly, malignant and highly vascular tumors demonstrate hyper-enhancement with contrast, whereas thrombi do not appear to enhance at all; myxomas tend to be

partially enhanced (3, 4). Attachment of a mass to an area of abnormal wall motion, typically akinesis or dyskinesis, makes the diagnosis of thrombus more likely than that of a tumor. Similarly, a valvular mass should raise greater concerns in a thrombotic (sterile) or infectious vegetation than a benign or malignant mass.

Transesophageal echocardiography (TEE), commonly used when a valvular lesion is suspected, may also become necessary to better characterize a cardiac tumor in terms of size, morphology, attachment site, extension and hemodynamic affects. However, not infrequently, this role is taken by cardiac magnetic resonance imaging (MRI) or cardiac computed tomography (CT). Echocardiography has a narrower field of view than MRI or CT in general and can be limited further by poor acoustic windows. Artifacts can be mistaken for true pathology, and echocardiography is unable to give a definite tissue histology, which is a general limitation.

The use of 3-dimensional (3-D) echocardiography is the newest approach in the assessment of intracardiac

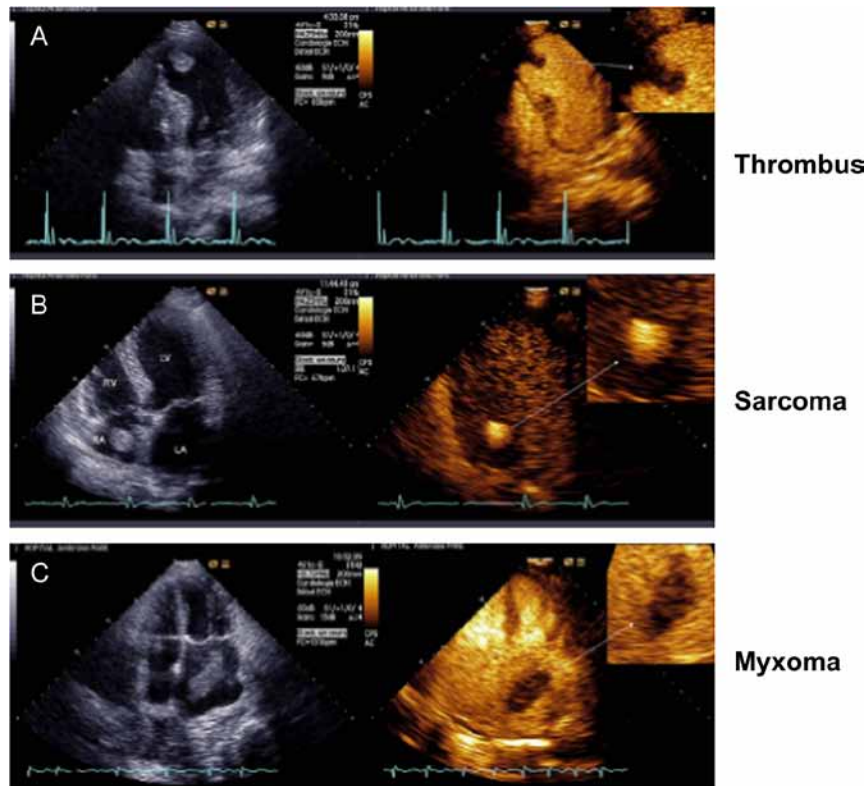


Figure 1

Illustration of the differences in presentation by echo contrast imaging of cardiac thrombus (A), sarcoma (B) and myxoma (C). Reproduced, with permission, from Mansencal N, Revault-d'Allonnes L, Pelage J-P, Farcot J-C, Lacombe P, Dubourg O. Usefulness of contrast echocardiography for assessment of intracardiac masses. *Archives of Cardiovascular Diseases* 2009; volume 102 (issue 3): 177–183. Copyright 2009 Elsevier Masson SAS. All rights reserved. (4).

masses. Three-dimensional echocardiography allows for a volumetric assessment of a mass over a linear measurement as it is obtained with 2-dimensional imaging. With the cropping techniques available with 3D, various aspects of the mass can be better visualized including point of attachment, homogeneity, vascularity, and calcification (5).

The symptoms a cardiac tumor causes are usually related to its cardiac location, although some may produce systemic complaints. Embolic phenomena are an example of the latter and may be the clinical first presentation

of the tumor. Most commonly, these are noted in the systemic circulation as tumors on the left side of the heart are associated with a greater risk of embolization (e.g. myxoma), but tumor embolism into the pulmonary circulation has been described as well (e.g. lymphoma) (6, 7). Hemodynamically, tumors reduce cardiac output (stroke volume) by causing intra-cavity obstruction or valvular dysfunction. Malignant tumors may invade the myocardium and pericardium resulting in arrhythmias, heart failure and pericardial effusions. Sudden death may also occur, and although infrequent, it can unfortunately be the initial and final manifestation of the tumor (8). In general, early identification of a cardiac tumor is ideal for treatment considerations and prognosis.

In clinical practice, whenever a cardiac mass is encountered on echocardiography, a pragmatic approach is to focus on the location first, and then on the imaging characteristics and subsequently the clinical context and presentation to reach the correct conclusions (Fig. 2). For instance, a mass on the aortic valve, pedunculated with sea anemone appearance in an asymptomatic adult patient most likely represents a fibroelastoma. A 'site differential' is provided in Fig. 3, and details of the specific entities by type of cardiac tumor will be provided in the following sections with particular attention given to the echocardiographic imaging characteristics (1, 9, 10).

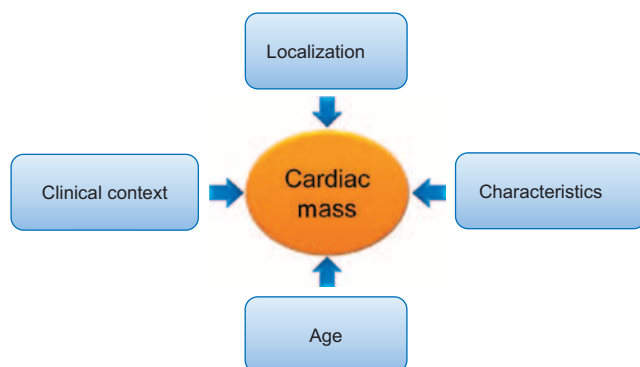


Figure 2

Conceptual initial approach to evaluate a cardiac mass.

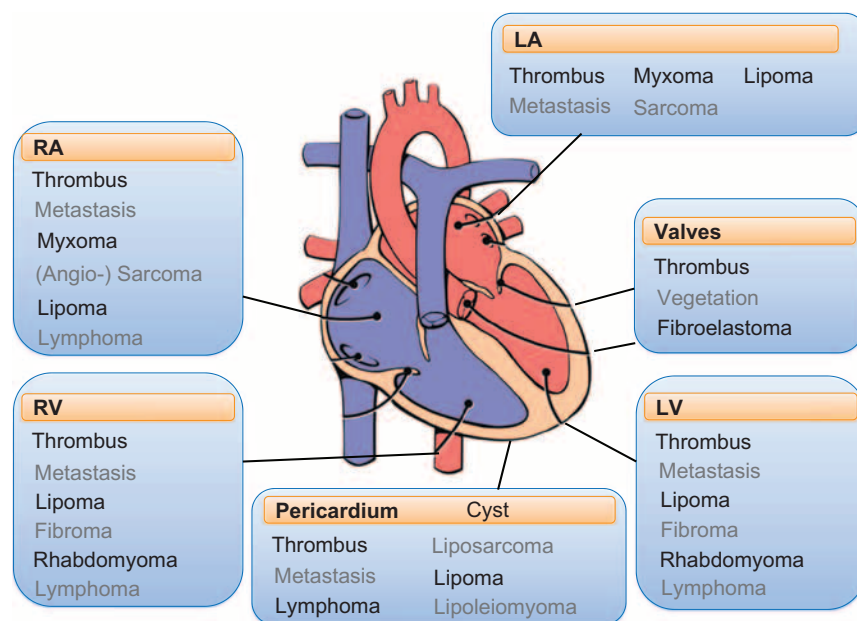


Figure 3

Outline of the distribution of subtypes of cardiac masses by anatomic location. Reprinted from *Journal of the American Society of Echocardiography*, Vol 13 issue 12, Dujardin KS, Click RL & Oh TK, The role of intraoperative transesophageal echocardiography in patients undergoing cardiac mass removal, Pages 1080–1083, Copyright (2000), with permission from Elsevier. (61).

Benign primary cardiac tumors

The majority of primary cardiac tumors are benign in nature (11, 12, 13). Of these benign cardiac tumors, cardiac myxomas by far are the most common entities in adults and rhabdomyomas in the pediatric population.

Myxoma

Cardiac myxomas are the most common primary cardiac tumor in adults, typically presenting between

the ages of 30 and 60 years and more commonly in women (14, 15, 16). The majority (75–80%) are located within the left atrium, characteristically originating from the mid-portion of the atrial septum by a narrow stalk; 15–20% originate within the right atrium (Fig. 4) (17). It is exceedingly rare to find a myxoma on the cardiac valves or within the left or right ventricle (Fig. 5) (18).

On echocardiogram, a myxoma presents as a heterogeneous mobile mass with one of the two basic appearances (Figs 4 and 5). Polypoid myxomas are larger with a smooth surface and a rough core including

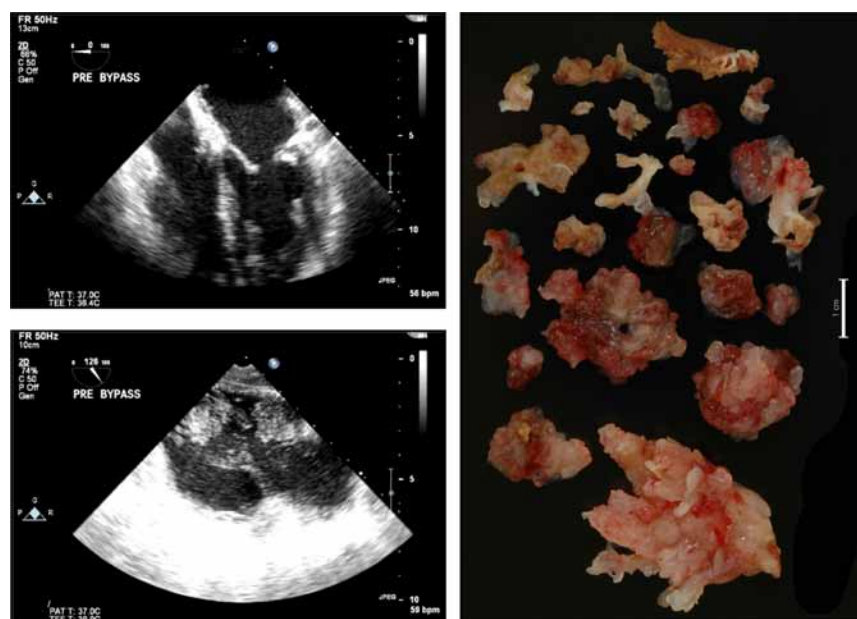


Figure 4

Atrial myxoma diagnosed in a 69-year-old female presenting with recurrent stroke, history of paroxysmal atrial fibrillation, on therapeutic doses of warfarin. Typical echocardiography images and their surgical pathology correlate on the left- and right-sided panels.



Figure 7
TEE image of a Lambl's in a 70-year-old male who presented with dysarthria and mild left-sided weakness, which resolved within an hour.

They are most commonly on the valves, primarily the aortic valve followed by the mitral valve, mainly in the downstream side, and most commonly 2 to 40 mm in size. Larger PFEs are seen when they occur on the right-sided valves.

Echocardiographic features of a PFE are small size, with independent motion and attachment to an endocardial surface (Fig. 6). Especially on TEE, the borders appear stippled or shimmering, which is due to the vibration at the tumor–blood interface due to the finger-like projections (28). The latter has been likened to a ‘sea anemone’ due to the frond-like arms attached to a central pedicle, best seen when the tumor is viewed under water. Distinguishing a PFE from a Lambl's excrescence may be difficult, but the latter is typically smaller and more linear (Fig. 7). TEE detects more PFEs than transthoracic echocardiography due to the typical small size of these tumors, thus reinforcing

the role of TEE in the evaluation of an embolic event (27).

A significant association is seen between a clinically diagnosed PFE and a thromboembolic event (27, 29, 30). Either the tumor itself or thrombi that have formed on the tumor embolize, most commonly causing a transient ischemic attack or stroke (29, 30). These tumors are more common in women and older patients (27, 29, 30). Although these tumors arise from the valvular endocardium, valvular dysfunction is rare (28).

Surgical excision is recommended for larger (≥ 1 cm), left-sided PFEs in patients who are deemed appropriate surgical candidates (young age, low surgical risk) or at the time of cardiac surgery for another cardiovascular condition (31). Right-sided PFEs should be removed only if large or mobile and associated with hemodynamically significant obstruction or risk of embolism such as can be seen with a patent foramen ovale with right-to-left shunting. Excision dramatically decreases the risk of stroke from a PFE (27). This approach may be prudent even for the incidental finding of a PFE in an asymptomatic patient unless they are small, without a stalk and thus non-mobile. In this case, and if surgery is not undertaken due to patient preference or high surgical risk, treatment with antiplatelet agents is recommendable despite limited supporting data (27).

Rhabdomyoma

Rhabdomyomas are the most common primary cardiac tumor in children, typically appearing before the first year. The majority are associated with tuberous sclerosis (32) and tend to be multiple. Rarely are these tumors

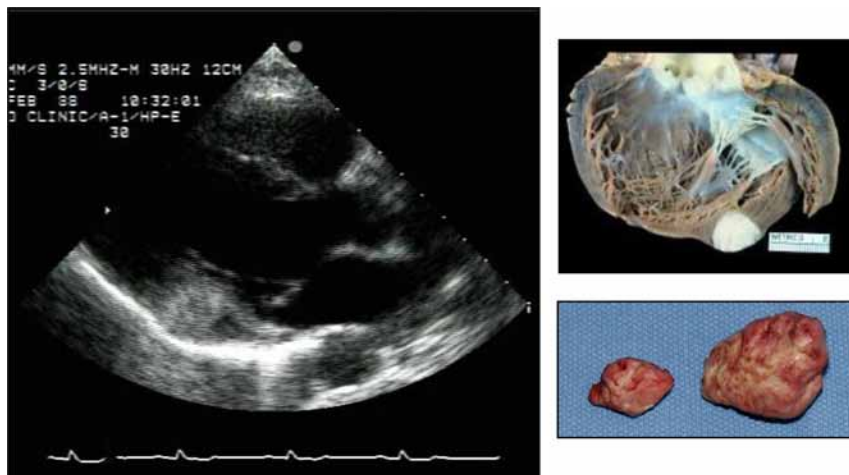


Figure 8
Echocardiographic images of a fibroma of a 47-year-old female with recent episode of chest pain and a history of possible tuberous sclerosis.

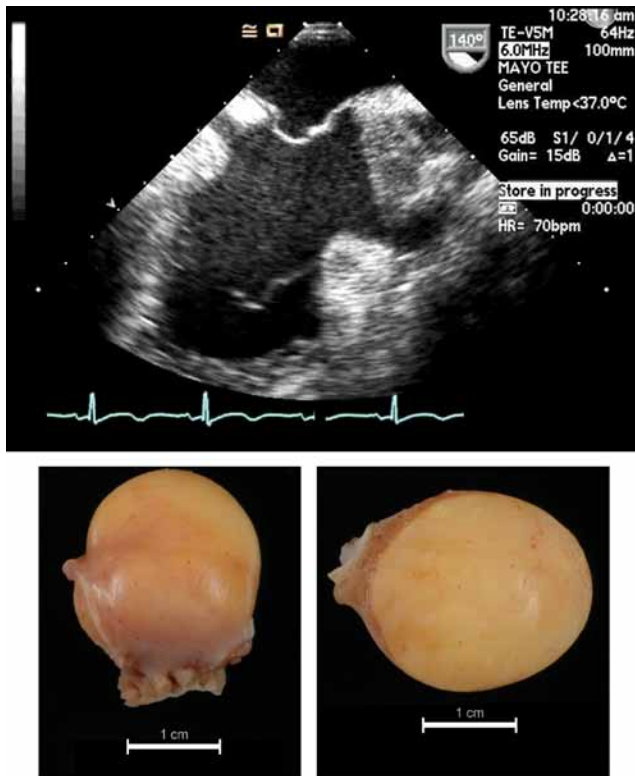


Figure 9

Lipoma diagnosed in a 47-year-old female presenting with chest pain and history of possible tuberous sclerosis. The echocardiographic image and its surgical specimen and cut section are presented in the top and the bottom left and right panel, respectively.

seen in adults. The rhabdomyomas are usually seen on the ventricular walls (left ventricle or ventricular septum) or on the atrioventricular valves. On the echocardiogram, they may appear as small, well-circumscribed (multiple) nodules or a pedunculated mass in a cardiac cavity. Myocardial embedding is possible, emerging as a lobulated, homogeneous and hyperechogenic mass (often brighter than the surrounding myocardium). Extensive growth and shrinkage are seen, and most of these tumors regress spontaneously (33). Thus, serial echocardiographic follow-up is key and often sufficient. Resection may be required if the cardiac mass causes obstructive symptoms or arrhythmias (33, 34).

Fibroma

Cardiac fibromas are rare, though still the second most common benign cardiac tumor in the pediatric population (35). On the echocardiogram, they usually appear as a distinct, well-demarcated, non-contractile and solid, highly echogenic mass within the myocardium; calcification is possible (Fig. 8). The most common locations are the left ventricular free wall, anterior free wall or ventricular septum. Extension into the cavity is not infrequent, which can lead to obstruction and heart failure symptoms. Otherwise, the myocardial location can lead to arrhythmias. These tumors do not spontaneously

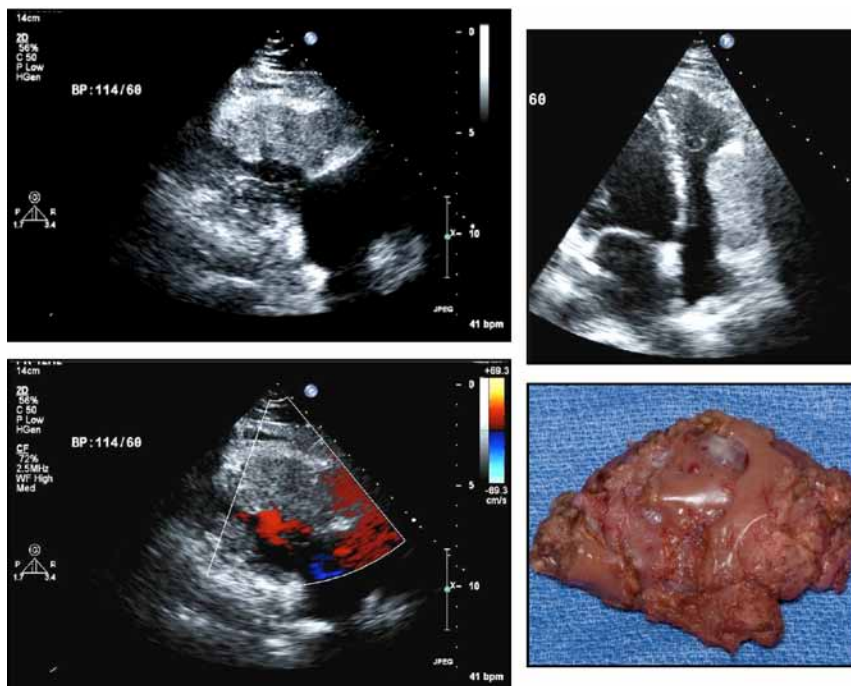


Figure 10

Hemangioma found accidentally in a 46-year-old male presenting with palpitations. The two upper panel images illustrate the echocardiographic presentation, the left lower panel illustrates the color Doppler mode indicating vascularity; the corresponding surgical specimen is presented in the lower right panel.

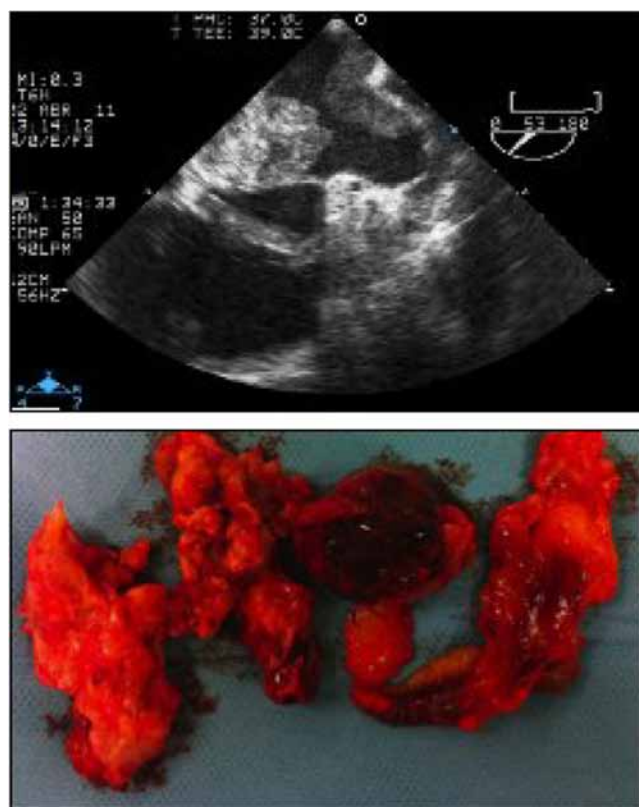


Figure 11

Typical echocardiographic presentation and surgical correlate (upper and lower panels) of a cardiac sarcoma. Reproduced with permission of the Publisher. Original source: Solla-Ruiz I, Villanueva-Benito I, Begoña Iglesias-Rodríguez M, Asorey-Veiga V, Yas SR, Pereira-Loureiro MA. Hemoptysis as the presenting symptom in cardiac sarcoma. *Revista Portuguesa de Cardiologia* 2012; 31: 463–464. Copyright 2012 Sociedade Portuguesa de Cardiologia. Published by Elsevier España, S.L. All rights reserved. (62).

regress and frequently require resection. Patients with multiple basal cell carcinomas should be screened for cardiac fibromas (Gorlin syndrome).

Lipoma

Lipomas are composed of benign adipose tissue. Within the heart, the majority of these arise in the subendocardium, but they can also occur in the pericardium and on the cardiac valves. Tumor size can range from a few to several centimeters. On echocardiography, lipomas tend to be broad based, immobile, without a pedicle and well circumscribed (Fig. 9). They are homogenous without evidence of calcification, hyperechoic in the cavity but hypoechoic in the pericardium. Typically lipomas are asymptomatic, but may cause arrhythmias or valvular dysfunction. Subepicardial lipomas may cause compression of the coronary arteries, leading to ischemic chest pain. Due to the progressive growth of lipomas along with the potential symptom profile, excision may be required.

Lipomatous hypertrophy of the interatrial septum is due to fatty infiltration of the proximal and distal portions of the atrial septum, generally with sparing of the fossa ovalis and most commonly seen in the elderly and obese (36). It is not a true tumor, although it can be mistaken for one, namely a myxoma or lipoma. The characteristic appearance and location aids in the differentiation. Resection is not required unless extremely rare symptoms related to it, such as atrial arrhythmias, heart block or caval obstruction, need to be addressed (37, 38).

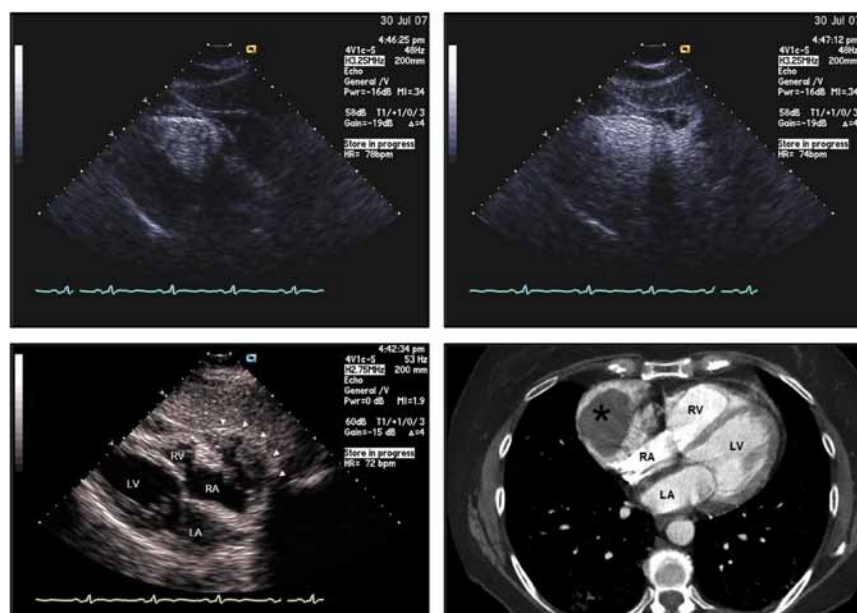


Figure 12

Example of an angiosarcoma diagnosed in a 63-year-old woman presenting with syncope and atypical chest pain. Reproduced, with permission, from Yang HS, Lee KS, Chaliki HP, Tazelaar HD, Lusk JL, Chandrasekaran K & Tajik AJ, Anomalous insertion of the papillary muscle causing left ventricular outflow obstruction: visualization by real-time three-dimensional echocardiography, *European Heart Journal: Cardiovascular Imaging*, 2008, volume 9, pages 733–738, by permission of Oxford University Press. (63).

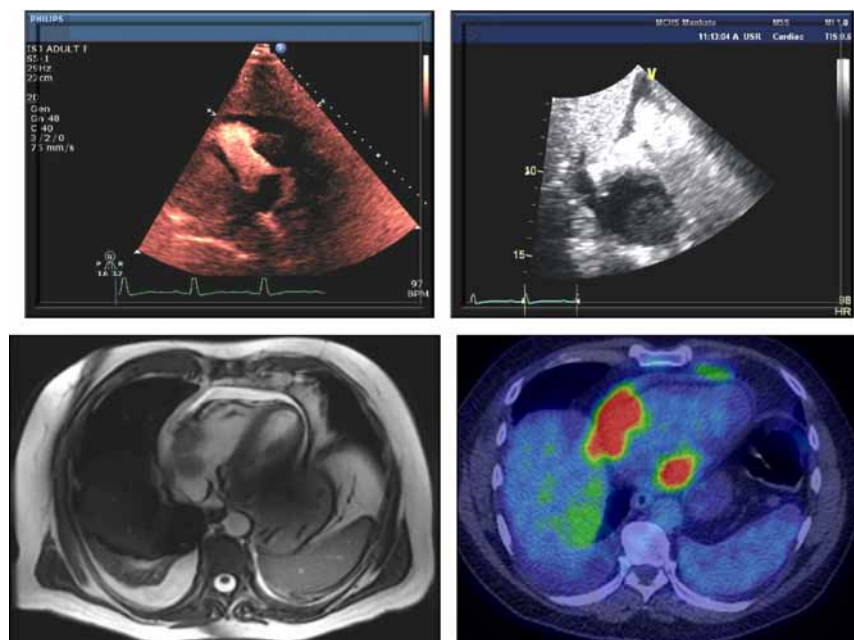


Figure 13

Cardiac lymphoma in a 55-year-old male presenting with RUQ abdominal pain. Echocardiogram, especially with echo contrast, shows a mass in the right ventricle (upper left panel) and right atrium (upper right panel), close to the lateral tricuspid valve, confirmed by cardiac MRI (lower left panel) and with high metabolic uptake on FTG-PET (lower right panel).

Other benign primary cardiac tumors

Hemangiomas, atrioventricular node tumors and teratomas are even rarer benign tumors that may occur within the heart. Hemangiomas are made up of dilated vascular channels; thus, their echocardiographic appearance is one of an echogenic mass with echolucencies (Fig. 10). They can be located within the endocardium, myocardium, epicardium or pericardium, and are commonly seen in the right ventricular free wall or the left ventricular lateral wall. Teratomas, which are extremely rare in adults, arise in the pericardium and can cause tamponade or extrinsic compression of the heart.

Malignant primary cardiac tumors

Malignant cardiac tumors constitute 15% of primary cardiac tumors (12). However, a tumor present only

on the right side of the heart has an almost 50% chance of being a malignant primary cardiac tumor (39). It is very rare for a malignant cardiac tumor to occur exclusively in places other than those within the cardiac chambers. Evidence of rapid growth, local invasion and hemorrhagic pericardial effusion are all additional signs of malignancies. A pericardial tumor is more commonly malignant as well (39). As with benign cardiac tumors, the clinical presentation can vary but typically is related to the location of the tumor. Precordial pain usually indicates a malignant rather than a benign process.

Sarcomas

Sarcomas are the most common of the malignant cardiac tumors typically diagnosed in individuals in their mid-40s (40). Undifferentiated sarcomas appear as a broad-based



Figure 14

Pericardial mesothelioma in a 41-year-old female referred to cardiology due to concerns about pericardial constriction and a six-month history of fevers, night sweats, weight loss, profound dyspnea, edema and cough.

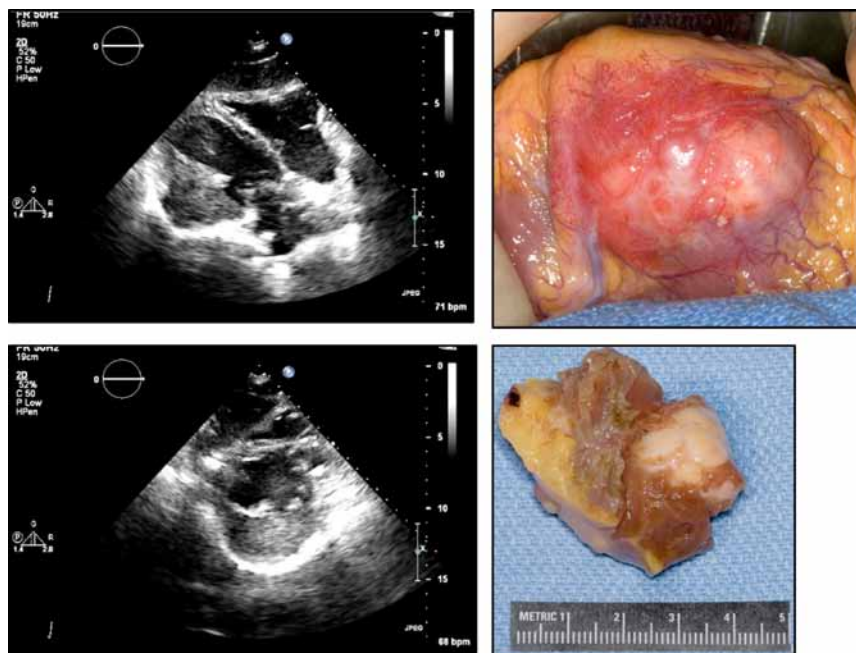


Figure 15

Metastasis of a renal cell carcinoma (RCC) in the left ventricular lateral wall in a 69-year-old man with a history of RCC, s/p nephrectomy, who presented with atypical chest pain.

mass on an echocardiogram, typically in the left atrium (differential diagnosis is a myxoma) with heterogeneous echogenicity; hypoechogenic areas may indicate tumor necrosis (Fig. 11).

Any type of sarcoma may develop in the heart (41), but the most common is the angiosarcoma. The predilection site is the right side of the heart, particularly the right atrium. Echocardiographically they emerge as lobulated masses, distinctly heterogeneous with an area of necrosis or hemorrhage (Fig. 12). They have no stalk, differentiating them from myxomas or PFEs. Even though vascular, contrast echocardiography may not always reveal significant enhancement, which may be due to the

slit-like vascular channels and the solid spindle cell areas (42). These tumors tend to have direct involvement with the pericardium, resulting in pericardial effusions, with or without tamponade. Interestingly, however, cytology on the pericardial fluid is frequently unrevealing (42). Angiosarcomas also tend to replace the right atrial wall and fill the cardiac chamber. In addition, as they develop near the right atrioventricular groove, the function of the tricuspid valve can be affected as well (42, 43). The signs and symptoms related to a cardiac angiosarcoma therefore often include pericardial chest pain, obstruction, congestion, dyspnea and fatigue (44). Unfortunately, metastatic disease (often to the lungs) is common at the

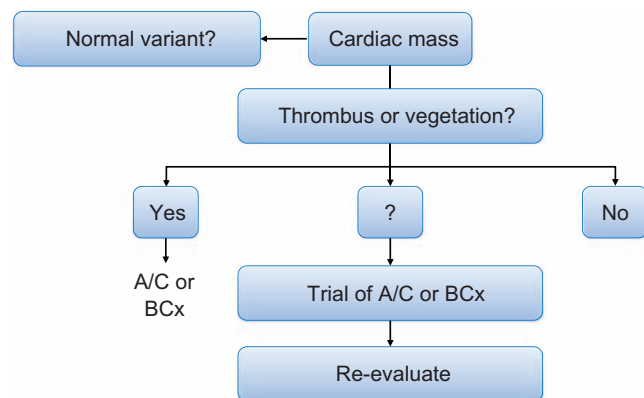


Figure 16

Illustration of the differential diagnostic algorithm for the diagnosis of a cardiac mass and principle #1 that thrombus or vegetation is often most likely. Reproduced from *Heart*, Bruce CJ, volume 97, pages 151–160, copyright 2011; with permission from BMJ Publishing Group Ltd. (31).

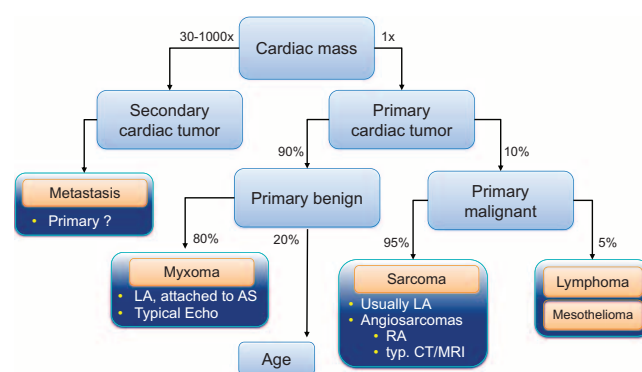


Figure 17

Illustration of the differential diagnostic algorithm for the diagnosis of a cardiac mass and principle #2 that cardiac tumors are most secondary and principle #3 that primary cardiac tumors are mostly benign. Reproduced from *Heart*, Bruce CJ, volume 97, pages 151–160, copyright 2011; with permission from BMJ Publishing Group Ltd. (31).

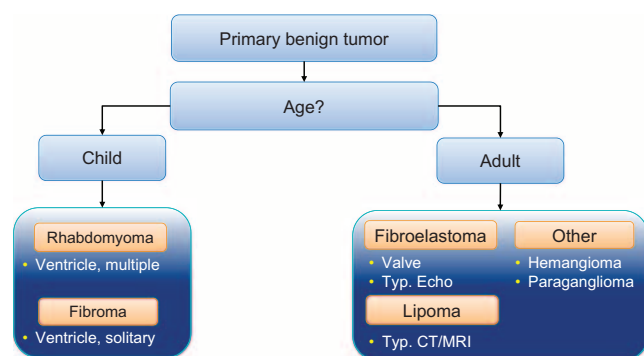


Figure 18

Illustration of the differential diagnoses for primary cardiac tumors by age. Reproduced from *Heart*, Bruce CJ, volume 97, pages 151–160, copyright 2011; with permission from BMJ Publishing Group Ltd. (31).

time of diagnosis in the majority of patients (45, 46). The prognosis is poor, and without resection, 90% of patients die within one year of diagnosis (47). Improved survival is seen with left-sided tumors that have not metastasized at the time of diagnosis (48). Even with metastatic disease, surgical debulking does have a survival advantage (42).

Rhabdomyosarcomas in some series are the second most common primary cardiac sarcoma and can arise from any cardiac structure; they do not seem to have a preference for any particular location (26). These tumors tend to occur in multiple sites within the heart and can cause obstruction at multiple levels (49). They grow rapidly and invade the pericardium early in their course resulting in a poor prognosis (48).

Leiomyosarcomas, osteosarcomas, fibrosarcomas and undifferentiated sarcomas are other rare primary cardiac sarcomas. Fibrosarcomas and undifferentiated sarcomas tend to be white fleshy tumors that have prominent

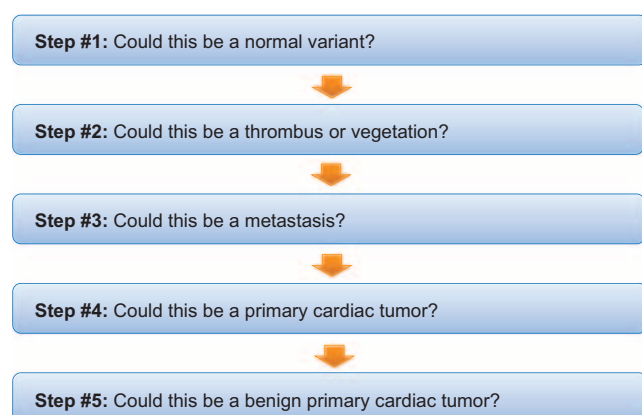


Figure 19

Pragmatic steps to be taken with the finding of a cardiac mass on echocardiogram.

areas of necrosis and hemorrhage (50). Leiomyosarcomas and osteosarcomas tend to occur more commonly in the left atrium.

Sarcomas in general grow rapidly, extensively and metastasize early. Complete resection is the most ideal option; however, metastatic disease and recurrence limit long-term survival even with complete excision (51, 52). Adjuvant chemotherapy and radiation have been attempted to improve the poor overall survival; however, no randomized trials have been undertaken (40). Radiation typically is used for metastatic disease (53).

Lymphoma

Cardiac lymphomas are less common than sarcomas. On autopsy, 16% of patients with Hodgkin disease and 18% of patients with non-Hodgkin lymphoma had notable cardiac involvement at a median of 20 months after initial diagnosis (54). Primary cardiac lymphomas on the other hand have been seen with increasing frequency in the immunocompromised host (55, 56), such as post-transplant or HIV patients. These tumors are most commonly diffuse large B-cell lymphomas. On echocardiography, they can appear as homogeneous, infiltrating masses leading to ‘wall thickening’ and restrictive hemodynamics or as nodular masses intruding into the heart chambers, preferentially the right heart chambers and especially the right atrium (Fig. 13). The AV groove can be affected as well, encasing the right coronary artery, as well as the pericardium with effusion or enfacement. TEE is the superior imaging technique and should be pursued when there is a need to identify these tumors (56). Depending on the location of the mass, signs and symptoms of inflow obstruction can be noted ranging from cava syndromes to constriction/restriction, heart failure and arrhythmias such as AV nodal block, and phenomena of embolism. Diagnosis can be made with cytology testing of pericardial fluid or by transvenous biopsy under echocardiographic guidance (56). This is a key step as the prognosis of lymphomas is generally much better than that of other primary cardiac masses if patients are eligible for suitable chemotherapy. Radiation therapy is less favorable, and surgical resection of the entire tumor is extremely difficult (56).

Mesothelioma

Malignant mesotheliomas account for half of the primary pericardial tumors. The other half of primary pericardial

tumors is benign (teratomas, fibromas and lipomas). Symptoms from a pericardial mesothelioma include chest pain, cough and palpitations (57). These tumors form bulky nodules within the pericardial cavity, encircling the heart, mimicking pericarditis, tamponade or pericardial constriction (57). Echocardiography typically reveals a pericardial effusion and a tumor encasing the heart; a discrete mass may not be seen (Fig. 14). Prognosis is poor, although surgery plus radiation can provide some palliative benefit (57).

Metastatic cardiac tumors

Metastatic involvement of the heart is not an uncommon occurrence. In autopsy series, metastasis to the heart occurs at a frequency of 0.7–3.5% in the general population, but increases to an average of 7.1% in persons with known malignancies (58). Metastases may occur through direct invasion of a nearby tumor, hematogenous spread, transvenous extension through the inferior vena cava or lymphatic spread. The most common tumors with metastatic potential to the heart are lung carcinoma, breast carcinoma, esophageal carcinoma, malignant lymphoma, leukemia and malignant melanoma. Malignant melanoma, due to its hematogenous spread, has the highest propensity to have cardiac involvement (59). The pericardium tends to be most commonly involved with metastases (60) and typically presents with a pericardial effusion, which may be asymptomatic. Renal cell carcinoma reaches the heart by extension through the inferior vena cava, but hematogenous metastases can also be seen (Fig. 15). Cardiac involvement should be suspected or sought in any patient with a known malignancy, who develops new cardiovascular signs or symptoms. Echocardiography should then be undertaken as the initial diagnostic test to evaluate for the presence of cardiac metastatic disease. However, other imaging modalities are frequently used to provide additional information and characterization of potential metastatic disease. Unfortunately, the presence of cardiac metastases occurs in patients with disseminated disease burden. Therefore, prognosis is typically poor when cardiac metastases are identified.

Conclusion

Cardiac tumors, both primary and metastatic, are frequently first found and/or evaluated by transthoracic echocardiography. Thrombus (Fig. 16) and vegetation are

the two most common entities. Most true cardiac tumors are secondary, i.e. metastatic, whereby malignant melanoma has the highest propensity to metastasize to the heart. Primary cardiac tumors are mostly benign and have a good prognosis, whereas malignant primary cardiac tumors are most commonly sarcomas and have a poor prognosis. Echocardiography is a readily available, portable, low-cost imaging modality, which gives the first clue as to the etiology of a cardiac mass; characteristics of a mass such as location, mobility, attachment and appearance can help determine whether a mass is benign or malignant. New techniques such as contrast echocardiography and three-dimensional echocardiography may further enhance the ability to determine with confidence the etiology of a cardiac mass. At the end, entertaining all possibilities, a stepwise approach may serve well in clinical practice (Figs. 16, 17, 18, 19).

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this review.

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