Masses of the heart. MR and CT findings

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Learning objectives

• To review and illustrate the radiological findings of cardiac masses.
• To classify cardiac tumors and pseudotumors based on the radiologic semiology and on their location.
• To describe the value of Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) in the diagnosis of cardiac masses.
• To illustrate on CT and MRI the hallmarks in diagnosis of thrombus, benign and malignant masses and non-neoplastic lesions presenting as heart masses.

Background

The cardiac masses include benign tumors, primary malignancies, metastatic involvement, and non-neoplastic lesions. They constitute an area of ongoing professional interest because its diagnostic and therapeutic challenges.

Echocardiography, CT and MRI have greatly added to the likelihood of timely diagnosis of these lesions and to the application of targeted interventions for their treatment.

The diagnosis of an intracardiac mass requires definition of its location, extent, hemodynamic effect, and tissue characteristics. CT and specially MRI are suited to provide this information.

Non-neoplastic masses can mimic cardiac tumors and should be recognized in order to avoid misdiagnosis.

We present selected images of cardiac masses of various etiologies from our own institution and we also review the CT and MRI characteristics of each type of tumor.

 Imaging findings OR Procedure details

We retrospectively reviewed the clinical records of 328 patients with cardiac masses diagnosed and/or treated at our tertiary-care hospital since 1994 to 2012.
Patients were selected from an administrative database using the following words as search criteria: cardiac surgery, heart, mass, thrombus and tumor. The total of cases presenting a CT and/or MRI study was 78. The remaining 250 cases were only studied by ecocardiography and excluded from this review.

Diagnosis was confirmed either by surgery, pathology, and/or necropsy and in other cases, the diagnosis was established by typical findings in two concordant imaging techniques and/or follow-up.

Based on its location cardiac masses were classified as: intracavitary (n =29), myocardial (n = 21), valvular (n = 9), and epicardial/pericardial (n = 19). Table 1 on page 30

The masses were most frequently found in the left atrium (26%), followed by epicardial/pericardial location (25%) and the right atrium (21%). Most prevalent masses were myxomas (21%), usually localized on left atrium, followed by metastasis (13%) and thrombus (12%). Less common masses were intracavitary lipoma (1.3%), myocardial tuberculoma (1.3%) and pericardial paraganglioma (1.3%).

1. INTRACAVITARY MASSES

Intracavitary masses were benign tumors (myxomas, lipomas), non-neoplastic lesions (thrombus) and metastasis.

BENIGN TUMORS

Myxomas

Myxomas are the most common benign tumor of the heart. In our series, these tumors were the most common cardiac masses studied by CT and/or MRI.

Most of them are solitary and sporadic lesions in adults between the fourth and seventh decade. About 7% of myxomas occur as part of the Carney complex and its subsets LAMB syndrome and NAME syndrome (comprising cardiac myxomas, bening skin tumors, lentigiosis, and endocrine overactivity).

Symptoms
Classic triad: cardiac obstructive symptoms related to the obstruction of blood flow, embolic events, and constitutional symptoms (fever, malaise and weight loss).

Thromboembolic events occur in 35% of left-sided myxomas to the brain, kidney, spleen and extremities and in 10% of right-sided myxomas to the lung.

**Location**

Left atrium (75%), typically arising from the interatrial septum in the region of the fossa ovalis.

Right atrium (20%).

Ventricles (5%).

**Imaging findings**

Myxomas are pedunculated or broad based well-defined spherical or ovoid intracavitary masses with lobular contours (Fig. 1 on page 31a). Large tumors may prolapse through the tricuspid (Fig. 1 on page 31b) or mitral (Fig. 2 on page 32) valve orifices.

Heterogeneity on CT and MRI is a common feature, related to hemorrhage, necrosis, cyst formation, fibrosis or calcification (Fig. 3 on page 33, Fig. 4 on page 34). On T1-weighted images, myxomas can be isointense, hyperintense or hypointense with respect to the myocardium. Areas of decreased signal intensity are due to calcification or magnetic susceptibility artifacts caused by hemosiderin.

Contrast material enhancement is usually heterogeneous which also likely reflects the presence of necrotic areas within the tumor. However, intense enhancement may be also seen (Fig. 5 on page 35).

**Treatment**

Complete surgical resection of the tumor is curative.

**Differential diagnosis**

Thrombus.
Non myxomatous neoplasms, most of which are malignant.

**Diagnostic clues**

A narrow base of attachment to the interatrial septum (Fig. 3 on page 33).

**Lipoma**

Cardiac lipomas account for 10% of all cardiac tumors at any age with equal gender frequency.

Most of them are solitary. Multiple lipomas have been reported in patients with congenital heart defects, tuberous sclerosis, and rarely in an otherwise normal heart.

Fifty percent of cardiac lipomas are intracavitary and subendocardial in origin.

**Symptoms**

Usually asymptomatic although, subendocardial lipomas may cause obstructive symptoms.

**Location**

The right atrium is the most common location.

However, it can be detected in any location: left atrium, right and left ventricles, heart valves, atrioventricular groove and pericardium,

**Imaging findings**

Lipomas in the right atrium usually have a wide peduncle originating either from the septal wall or the atrial roof.

Echocardiographic findings are nonspecific and appear as homogeneous and hyperechoic masses.

Findings on MRI are specific: homogeneous hyperintense signal on T1-weighted images with signal dropout on the fat-saturation sequences (Fig. 6 on page 36).
Like soft-tissue lipomas, cardiac lipomas do not enhance with the administration of contrast material.

**Treatment**

Depending on the size, location and functional repercussion, this sort of tumors can be let alone or resected.

Surgical resection is curative.

**Differential Diagnosis**

Myxoma

Fibroelastoma

**Diagnostic clues**

Supression of signal on fat-saturation sequences.

**NON NEOPLASTIC LESIONS**

**Thrombus**

In our series, intracavitary thrombus was the second most common cardiac mass studied by CT and/or MRI.

Thrombus can be associated with heart diseases such as myocardial infarction, valve protheses, endocarditis, rhythm abnormalities, Löffler's endocarditis or cardiac tumors.

Systemic diseases associated with cardiac thrombus include vein thrombosis, central venous catheters, coagulopathies, chronic anabolic steroid abuse, Behçet's syndrome and Churg-Strauss syndrome among others.

**Symptoms**

Arterial or pulmonary embolisms should be addressed as life-threatening conditions.
Embolic risk: mobile or protruding thrombi (50%), non-mobile or flat thrombi (10%).

**Location**

It could be seen in any chamber. Location is related to the underlying heart disease or systemic diseases.

Most common: left ventricular apex (myocardial infarction) and left atrial appendage (mitral stenosis and atrial fibrillation).

**Imaging findings**

Thrombi may have a polipoid shape, pediculate and mobile similar to myxomas. In contrast with myxomas, thrombi do not usually show prolapse through the heart valves.

Echocardiography is the most sensitive technique for the detection of intracardiac thrombus. However, differentiating intracardiac thrombus from tumor can be challenging.

On CT scan, thrombus appears as a low-attenuation structure surrounded by contrast filling the cavity (Fig. 7 on page 37).

Delayed-enhancement MR sequences are particularly sensitive for detecting thrombi, as dark structures surrounded by contrast-enhanced blood (Fig. 8 on page 38).

**Treatment**

Anticoagulation therapy

**Differential diagnosis**

Myxoma

Slow blood flow

**Diagnostic clues**

Non-enhanced intracavitary filling defect, usually associated with myocardial infarction or atrial fibrillation.
MALIGNANT TUMORS

Metastases

Cardiac metastases are far more common than primary tumors and of utmost importance when considering patients with disseminated disease.

Direct extension and hematogenous spread are the two most common ways of cardiac involvement. Venous and lymphatic spread of the metastases to the heart are relatively rare.

Abdominal and pelvic tumors may grow into the inferior vena cava and extend into the right atrium. Thyroid and thymic tumors may also extend into the right atrium through the superior vena cava and lung carcinomas often use pulmonary veins to reach the left atrium.

Symptoms

Patients may be asymptomatic or present with arrhythmias, or even symptoms related to right heart obstruction.

Location

The dissemination through the inferior vena cava, makes the right atrium the most common location.

Imaging findings

A mass in the inferior vena cava lumen extending to the right atrium could be seen either on echography, CT or MR imaging.

These lesions may demonstrate hypervascularity on dynamic imaging after intravenous contrast administration (Fig. 9 on page 39).

Primary tumor as Hepatocellular Carcinoma and Renal Carcinoma (Fig. 10 on page 40) can be seen in the same examination.

Treatment

Chemotherapy related to the primary neoplasm.
In some cases and mostly depending on the extension and the primary tumor surgical resection could be performed.

**Differential diagnosis**

Thrombus or blood clot

**Diagnostic clues**

Enhanced intracavitary mass with transvenous extension of primary tumor to the heart.

2. MYOCARDIAL MASSES

NON-NEOPLASIC LESIONS

*Lipomatous infiltration of the interatrial septum*

It is a benign condition characterized by excessive fat deposition in the interatrial septum.

It is associated with obesity and advanced age and has a higher prevalence in women.

**Symptoms**

Most patients are asymptomatic.

It is usually an incidental finding at cardiac imaging, surgery, or autopsy.

**Location**

Interatrial septum sparing of the fossa ovalis.

**Imaging findings**

Characteristic imaging findings include a dumbbell-shaped fatty mass resulting from sparing of the fossa ovalis and no contrast enhancement.
Homogeneous low attenuation on CT (<50HU) (Fig. 11 on page 41), signal intensity similar to mediastinal fat on MRI and signal dropout on the fat-saturation sequences (Fig. 12 on page 42)

**Treatment**

It is not required.

In some cases associated with rhythm anomalies, medical therapy is established.

**Differential diagnosis**

Cardiac lipoma

**Diagnostic clues**

Specific location and shape.

**Intramural hematoma**

Intramural atrial hematomas are extremely rare.

They have been described either as spontaneous or secondary to mitral valve surgery, infective endocarditis, dissection of the atrial wall, blunt chest trauma, myocardial infarction, cardiac amyloidosis and iatrogenia (percutaneous coronary interventions or radiofrequency catheter ablations).

**Symptoms**

Acute symptoms are heralded by chest pain, dyspnea and/or heart failure.

Sometimes this condition may mimic an acute aortic syndrome.

**Location**

Usually described at left atrial wall.

**Imaging findings**
Well-defined oval shaped myocardial mass.

Hyperdense mass on unenhanced CT (Fig. 13 on page 43) which also do not enhance after contrast material injection.

Variable signal intensity on T1 and T2-weighted images depending on the time elapse from the start of the haemorrhage.

**Treatment**

Conservative or surgical treatment with drainage are indicated depending on clinical presentation.

**Differential diagnosis**

Myocardial tumors.

**Diagnostic clues**

Hyperdense mass on non-contrast CT.

Non-enhancement after intravenous contrast administration.

**BENIGN TUMORS**

**Rhabdomyoma**

Rhabdomyomas are the most common primary cardiac tumors in children, being usually diagnosed in neonate.

They can be sporadic, but rhabdomyomas have a strong association with tuberous sclerosis, which should be considered if multiple tumors are present.

**Symptoms**

Asymptomatic (most common).
Unusually life-threatening cardiac failure due to left ventricular outflow tract obstruction or arrhythmias.

**Location**

Ventricular myocardium.

**Imaging findings**

Multiple, solid and homogeneous myocardial masses.

Hypodense to myocardium on contrast-enhanced CT.

Isointense with myocardium on T1-weighted and hyperintense on T2-weighted images with variable enhancement pattern (Fig. 14 on page 43, Fig. 15 on page 44).

When small diffuse intramyocardial lesions are present, diffuse myocardial thickening may be the predominant feature on echocardiography and CT scan. Contrast-enhanced MRI can be used to better define the borders of these tumors.

**Treatment**

Most cardiac rhabdomyomas regress spontaneously.

Surgery is not routinely required unless the patient develops significant symptoms from life-threatening arrhythmias or heart failure.

**Differential diagnosis**

Fibroma.

**Diagnostic clues**

Multiple ventricle nodules usually discovered on a child, frequently affected by tuberous sclerosis.

These tumors often regress spontaneously at the adulthood.
The absence of calcifications helps differentiation of rhabdomyomas from fibromas, which do show calcification.

**Lipoma**

Myocardial lipomas account for 25% of cardiac lipomas.

**Symptoms**

They usually do not cause symptoms and are incidentally discovered.

Intramyocardial lipomas have been associated with a variety of arrhythmias including atrial fibrillation, ventricular tachycardia, and atrioventricular block.

**Location**

Cardiac lipomas are usually intracavitary from a subendocardial origin.

A 25% are intramyocardial, whereas the remaining 25% are epicardial and extracavitary.

**Imaging findings**

Circumscribed, spherical or elliptical mass with homogeneous low attenuation on CT (<50HU) and signal intensity similar to mediastinal fat on MRI and signal dropout on the fat-saturation sequences (Fig. 16 on page 45, Fig. 17 on page 45).

They do not enhance after contrast material administration.

Encasement of the coronary arteries may occur. Therefore information regarding the relationship of the mass will be crucial for preoperative planning.

**Treatment**

Depending on the size, location and functional repercussion they can be let untreated or on the contrary, require surgical resection.

Surgical resection is usually curative and recommended in symptomatic patients.
**Differential diagnosis**

Lipomatous metaplasia in chronic myocardial infarcts.

Physiologic myocardial fat.

Arrhythmogenic right ventricular cardiomyopathy.

**Diagnostic clues**

Intramyocardial lipomas are easily distinguished from these entities by the presence of mass effect.

**MALIGNANT TUMORS**

**Metastases**

Most cardiac metastases occur in patients with widespread malignancy and are rare as an isolated event. Most of them are originated in the lung or breast and, less often, from melanoma, lymphoma, leukemia.

Isolated myocardial metastases are infrequent and usually associated with melanoma or lymphoma spread via hematogenous pathways.

**Symptoms**

Many are asymptomatic.

Patients may present arrhythmias, pericardial tamponade, congestive cardiac failure, or death secondary to coronary artery invasion.

**Location**

The left ventricular lateral wall and the ventricular septum, are the most common sites for these myocardial lesions.

**Imaging findings**
On CT, the masses are usually isodense or hypodense to the myocardium with heterogeneous enhancement (Fig. 18 on page 46, Fig. 19 on page 47).

On MRI, myocardial metastases usually have low signal intensity on T1-weighted images and high signal intensity on T2-weighted images (Fig. 18 on page 46).

Unlike other tumors, melanoma appears bright on T1-weighted images, an effect attributed to paramagnetic metals bound by melanin.

These lesions may demonstrate hypervascularity on perfusion imaging and delayed enhancement.

**Treatment**

Chemotherapy related to the primary neoplasm.

**Differential diagnosis**

Primary benign and malignant tumors.

**Diagnostic clues**

Intramural nodular deposits within the myocardium in an adult with a known primary malignancy would be highly suspicious of metastases, and should prompt screening for those malignancies that tend to spread via hematogenous pathways.

**Angiosarcoma**

Angiosarcoma is the most prevalent of the cardiac sarcomas and usually affects of men aged between 20 to 50 years old.

**Symptoms**

Obstructive symptoms and cardiac tamponade.

**Location**

Unlike other sarcomas, angiosarcomas usually arise in the right atrium or pericardium.
This tumor may spread along the epicardial surface, replace the right atrial wall and protrude into or fill the adjacent cardiac chamber.

**Imaging findings**

Angiosarcoma usually demonstrates a broad based right atrial infiltrating multilobular mass near the inferior vena cava. Epicardial, endocardial and intracavitary extension is common.

On contrast CT, these heterogeneously enhancing lesions appear irregular and hypodense.

On T1-weighted and T2-weighted image images, hyperintense hemorrhagic nodular areas against a background of intermediately intense heterogeneity create an appearance which some have likened to a cauliflower (Fig. 20 on page 48).

Marked heterogeneous enhancement after intravenous gadolinium contrast administration is usually seen.

**Treatment**

Heart transplantation has been performed in patients with unresectable cardiac sarcoma with satisfactory results.

Aggressive surgery can offer palliation of symptoms and may improve survival.

Chemotherapy and radiation therapy have not proved beneficial.

**Differential diagnosis**

Other primary cardiac sarcomas

Lymphoma

**Diagnostic clues**

Highly vascularized infiltrating mass in the right atrium. Other primary cardiac sarcomas predominate in the left atrium and present slow infiltrative growth patterns.
Primary cardiac lymphoma usually occurs in immunocompromised subjects and appears as a lobulated right atrial mass.

**Leiomyosarcoma**

Malignant tumor that usually occurs in the left atrium. Patients with leiomyosarcoma typically develop 5-10 years earlier than those with other cardiac sarcomas.

**Symptoms**

Dyspnea is the most common presenting complaint. Patients may also present with pericardial tamponade, systemic embolism, chest pain, syncope, pneumonia, fever, arrhythmias, peripheral edema, and sudden death.

**Location**

Leiomyosarcoma usually occurs in the left atrium.

**Imaging findings**

On CT a mass with a broad-based tumor attachment (Fig. 21 on page 49); usually with myocardial, pericardial, and mediastinal invasion; as well as extension into the great vessels and pulmonary metastases, and associated with pericardial effusion.

MRI appears to be isointense or hypointense to myocardium on T1-weighted images, hyperintense on T2-weighted images, and markedly enhancing with gadolinium contrast material.

**Treatment**

Aggressive surgery offers significant palliation of symptoms and improves survival. However early local recurrence and metastatic disease occur frequently tend to occur.

Heart transplantation has been performed in patients with unresectable cardiac sarcoma with satisfactory results.

Chemotherapy and radiation therapy have not proved beneficial for the treatment of affected patients.
**Differential diagnosis**

Other primary cardiac sarcomas and myxomas.

**Diagnostic clues**

Left atrium broad-based tumor with invasion of adjacent structures.

### 3. VALVULAR MASSES

Masses located in heart valves may be caseous degeneration of the mitral annulus, vegetations, perivalvular abscess, or papillary fibroelastoma.

**Caseous degeneration of the mitral annulus**

It is a rare form of mitral periannular calcification that generally appears as a large spherical mass.

Calcification undergoes a central degenerative softening, producing a caseous appearance.

**Symptoms**

It is usually an incidental finding in asymptomatic patients or in patients sustaining mitral stenosis or regurgitation.

**Location**

Adjacent to the posterior mitral leaflet or in the posterolateral atrioventricular groove, sometimes extending to the whole mitral annulus.

**Imaging findings**

Well-defined mass of variable attenuation and a peripheral calcification on CT scan.

The mass is usually hypointense on T1-weighted and T2-weighted images (Fig. 22 on page 50).

**Treatment**
Differential diagnosis

Tuberculoma and perivalvular abscess.

Diagnostic clues

The location in the atrioventricular groove and the typical peripheral calcification.

Caseous degeneration of the tricuspid annulus

It is very rare and present with similar findings as the mitral periannular calcification which generally appears as a large spherical mass (Fig. 23 on page 51).

4. EPICARDIAL/PERICARDIAL MASSES

Most epicardial and pericardial masses were malignant tumors (metastases, lymphoma) followed by non-neoplastic lesions (pleuropericardial cysts, loculated effusions, tuberculosis, coronary aneurysm) and benign tumors (lymphangioma, pheochromocytoma).

NON-NEOPLASTIC LESIONS

Pericardial Cyst

Pericardial cysts are benign lesions accounting for 5%-10% of all mediastinal masses.

Symptoms

Most patients are asymptomatic.

Patients may present episodes of dyspnea, retrosternal discomfort, or arrhythmia.

Location

Right cardiophrenic angle.
**Imaging findings**

Well-defined, round or oval masses in the cardiophrenic angle.

On CT, they have the same attenuation as water and do not enhance after contrast material administration.

Low or intermediate signal intensity on T1-weighted images and homogeneous high intensity on T2-weighted images. They do not enhance with the administration of contrast material (Fig. 24 on page 53).

Hyperintensity, corresponding hemorrhagic or proteinaceous contents, on T1-weighted images usually occurs in complicated cysts.

**Treatment**

Surgical resection of the cyst should be performed only in symptomatic patients.

**Differential diagnosis**

Mediastinal cystic lesions (enteric duplication cysts, thymic origin masses and cysts, and bronchogenic cysts).

Encapsulated pericardial effusions and intrapericardial hematomas.

Pericardial diverticulum.

**Diagnostic clues**

Location in right cardiophrenic angle.

A pericardial cyst in an unusual location may be indistinguishable from a bronchogenic cyst or thymic cyst.

A pericardial diverticulum, unlike a pericardial cyst, communicates with the pericardial cavity.

**Pericardial loculated effusion**
Pericardial loculated effusion caused by obstruction of venous or lymphatic drainage from the heart or after cardiac surgery can mimic a cardiac mass.

**Symptoms**

Asymptomatic or suddenly develop symptoms such as cough, dyspnea and cardiac failure.

**Location**

It can be loculated in any part of the pericardium.

**Imaging findings**

Lenticular morphology.

A fluid collection with attenuation close to that of water is likely to be a simple effusion. Attenuation greater than that of water suggests malignancy, hemopericardium, purulent exudate, or effusion associated with hypothyroidism (Fig. 25 on page 53).

Non-haemorrhagic fluid has low signal intensity on T1-weighted images and high intensity on T2-weighted images. Hemorrhagic effusion shows high signal intensity on T1-weighted images and low intensity on T2-weighted images.

Pericardial loculated effusion does not enhance with the administration of contrast material (Fig. 26 on page 54).

**Treatment**

Conservative management in asymptomatic patients.

Pericardiocentesis or surgical drainage is required in symptomatic patients.

**Differential diagnosis**

Pericardial cyst

Hematoma
Pericardium malignancy

**Diagnostic clues**

Lenticular morphology and not enhancement after contrast material administration.

**Pericardial Tuberculosis**

Tuberculous pericarditis represents only 1-2% of all tuberculous infections, yet it remains a serious condition because of a high incidence of progression to constrictive pericarditis with and a high mortality rate.

It is commonly caused by extranodal extension of tuberculous lymphadenitis into the pericardium.

The pericardium can also be involved in miliary spread of the disease.

**Symptoms**

Cough, chest pain and dyspnea.

It also can present associated to fever, cardiac arrhythmias and heart failure.

**Location**

Diffuse pericardial involvement.

**Imaging findings**

On CT, tuberculous pericarditis appears as smooth or irregular pericardial thickening, pericardial fluid collection, or concurrent tuberculosis in the lungs. Calcification is usually seen on constrictive pericarditis (Fig. 27 on page 55).

On MRI, low signal pericardial thickened reflect ferromagnetic elements after haemorrhage into the pericardial space as well as fibrosis of the pericardium. Linear low signals in the pericardial sac and enhancement of fibrous pericardium suggest inflammatory changes in the pericardium.

**Treatment**
Antituberculous therapy.

**Differential diagnosis**

Mesothelioma

Pericardial metastasis

**Diagnostic clues**

Clinical information.

Definitive diagnosis of tuberculous pericarditis is based on identifying tubercle bacillus in the pericardial effusion or pericardium biopsy.

**Coronary Aneurysm**

Coronary artery aneurysms are characterized by a 50% or greater increase in coronary diameter compared with adjacent arterial segments.

Giant coronary aneurysms (greater than 20 mm in adults and 8 mm in children) are rare with an incidence of 0.02%.

Kawasaki disease is the most frequent cause of coronary aneurysms worldwide, but in western countries atherosclerotic coronary disease is the most common cause (50%), followed by congenital (17%) and infectious (10%) causes.

**Symptoms**

Most patients are asymptomatic.

Symptoms include myocardial ischemia, rupture with associated fistula, cardiac tamponade and haemopericardium, thrombosis, dissection, and vessel compression.

**Location**

Right coronary artery and left anterior descending artery.
**Imaging findings**

Coronary angiography is considered the gold standard for diagnosing coronary aneurysms.

If the aneurysm contains substantial thrombus, its true size may be underestimated on catheter angiography.

ECG-gated MDCT allows a rapid and accurate delineation of the size and shape of aneurysms. MDCT also enables high-quality 2D and 3D reformations, which may be valuable in showing spatial relations among the aneurysm, the great vessels, and the heart. They may appear as sacular or fusiform mass in a coronary territory with linear peripheral calcifications and homogeneous or heterogeneous enhancement during arterial phase of contrast-enhanced CT (Fig. 28 on page 56).

MRI offers an alternative imaging technique for evaluating coronary artery aneurysms (Fig. 29 on page 57). However, the spatial resolution of MRI is inferior to that of CT.

Angio-MR 3D sequences after administration of contrast material show enhancement of the lumen similar to that of the cardiac chambers or the aortic lumen (Fig. 30 on page 58).

**Treatment**

In patients with coronary artery disease, treatment is guided by the underlying coronary artery stenosis.

In the absence of obstructive coronary artery disease, treatment continues to be a dilemma. Conservative treatment consist of attempts to prevent thromboembolic complications with anticoagulant therapy and administration of antiplatelet drugs.

Surgery is indicated in patients with obstructive coronary artery disease or evidence of embolism and in those patients with evidence of enlargement of saccular coronary artery aneurysms with increased risk of rupture.

Percutaneous treatment with either noncovered or coated stents is another option in patients with a fistula that needs closure.
In Kawasaki disease, the use of high-dose intravenous therapy with #-globulin, together with aspirin, reduces the rate of occurrence of coronary lesions.

**Differential diagnosis**

Vascular mass with linear peripheral calcifications in a coronary territory.

**Diagnostic clues**

Abnormal dilatation of coronary arteries.

**BENIGN TUMORS**

**Lymphangioma**

Lymphangiomas involving the heart are exceptional.

**Symptoms**

Most patients are asymptomatic.

Arrhythmias, palpitations, pericardial effusion, syncope and sudden death are less frequent.

**Location**

Pericardial space.

**Imaging findings**

Unenhanced well-defined or infiltrating low attenuation mass on CT after contrast material administration.

Low signal intensity on T1-weighted images and homogeneous high intensity on T2-weighted images. They do not enhance with the administration of contrast material (Fig. 31 on page 59).

On T1-weighted images, hyperintensity, corresponding to metahemoglobin, fat or protein in the lymphatic fluid can be seen.
Treatment
Imaging follow-up to monitor the spontaneous regression in asymptomatic patients.

Surgery in symptomatic patients.

Differential diagnosis
Complex pericardial effusion

Hemangioma

Cystic teratoma

Diagnostic clues
Well-defined or Infiltrating pericardial cystic mass without enhancement after contrast material administration.

Paraganglioma
Rare neoplasm which arise from neuroendocrine cells in the distribution of normal cardiac ganglia. Most lesions are found in adult patients from 18 to 85 years old.

Up to 20% of patients have associated paragangliomas in other locations (carotid body, adrenal gland, bladder, paraaortic), and 5% of patients may have osseous metastases.

Laboratory abnormalities such as elevated levels of urinary norepinephrine, vanillylmandelic acid and total metanephrine or elevated levels of plasma norepinephrine and epinephrine are highly suggestive of the diagnosis of a paraganglioma.

Symptoms
Symptoms are related to the excess of catecholamine secretion (paroxysmal hypertension accompanied by headache, sweating and palpitations).

Location
Epicardial surface of the base of the heart and in the roof of the left atrium.

Less common locations include the atrial cavity, interatrial septum and, even more rarely, the ventricles.

**Imaging findings**

Isoattenuated mass on unenhanced CT and intense enhancement with non-enhanced central areas after intravenous contrast administration.

Tumoral calcification may also be identified.

Iso or hyperintense on T1-weighted images, hyperintense on T2-weighted images and pronounced enhancement with non-enhanced areas after gadolinium administration (Fig. 32 on page 61).

**Treatment**

Surgery

**Differential diagnosis**

Pericardial hemangioma

**Diagnostic clues**

Clinical information and laboratory findings.

**MALIGNANT TUMORS**

**Metastases**

Metastases to the heart and pericardium are generally associated with poorer prognosis than primary cardiac tumors.

Direct extension and hematogenous spread are the two most common ways of cardiac involvement. Other less common pathways are retrograde lymphatic extension and venous extension.
**Symptoms**

Metastatic involvement of the heart and pericardium may go unrecognized until autopsy.

Impairment of cardiac function (30% of patients) attributed to pericardial effusion

Patients may also present with cough, anterior chest pain, pleuritic chest pain, or peripheral edema.

**Location**

Epicardium is the most common site of heart metastases, followed by the pericardium (Fig. 33 on page 61) and myocardium.

Endocardial metastases are rare but are more commonly seen in renal cell cancer, hepatocellular cancer, or melanoma and typically involving the right heart.

The intra-abdominal and pelvic tumors grow into the inferior vena cava and may extend into the right atrium.

Thyroid and thymal tumors may extend into the right atrium through the superior vena cava and lung carcinomas often use pulmonary veins to reach the left atrium.

**Imaging findings**

Pericardial effusion is the most common imaging manifestation of metastatic disease. They are frequently haemorrhagic and have high signal intensity on T1-weighted images.

Nodular pericardial implants, infiltrating mass, complex pericardial effusions or loculated pericardial effusions are suggestive findings.

An haemorrhagic pericardial effusion can be seen in association with metastases from any primary site.

**Treatment**

Chemotherapy
**Differential diagnosis**

Any disease process that causes thickening or nodularity of the pericardium or myocardium or masses within the cardiac chambers.

**Diagnostic clues**

Nodular or irregular pericardial thickening and mediastinal lymphadenopathy.

Biopsy may be necessary for the diagnosis, especially in patients with malignant disease and in areas where tuberculosis is endemic.

**Lymphoma**

Cardiac involvement of disseminated non-Hodgkin’s lymphoma is much more common than primary cardiac lymphoma.

Almost all primary cardiac lymphomas are aggressive B-cell lymphomas, most commonly occurring in immunocompromised patients.

**Symptoms**

Dyspnea, congestive heart failure, pericardial effusion.

Cardiac arrhythmias and nonspecific electrocardiographic abnormalities (atrioventricular blocks ranging from first degree to third degree).

**Location**

Primary cardiac lymphoma affects most frequently to the right atrium.

More than one cardiac chamber is involved in over 75% of cases.

Contiguous invasion of the pericardium is typical in secondary infiltration by mediastinal lymphoma (Fig. 34 on page 62).

**Imaging findings**
Ill-defined, infiltrating epicardial or myocardial mass, often with an associated pericardial effusion.

The tumor tends to extend along the epicardial surfaces of the heart, primarily encroaching or impinging on adjacent structures including coronary arteries and the aortic root.

Iso or hypoattenuated mass on unenhanced CT and heterogeneous enhancement after administration of intravenous contrast material.

Hypointense on T1-weighted images and hyperintense on T2-weighted images. (Fig 34) Contrast enhancement may be homogeneous or heterogeneous. Delayed-enhancement imaging with nulling of normal myocardium aids in identifying the extent of tumor.

**Treatment**

Chemotherapy

**Differential diagnosis**

Metastatic lung carcinoma

Angiosarcoma

**Diagnostic clues**

Extend along the epicardial surfaces of the heart encasing adjacent structures.

**Images for this section:**
<table>
<thead>
<tr>
<th>Location (n = 78)</th>
<th>Non-neoplastic</th>
<th>Benign Neoplasm</th>
<th>Malignant Neoplasm</th>
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<td><strong>Intracavitary (n = 8)</strong></td>
<td>Thrombus (n = 1)</td>
<td>Myxoma (n = 5)</td>
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<td><strong>Myocardial (n = 8)</strong></td>
<td>Lipomatous hypertrophy of interatrial septum (n = 4)</td>
<td>Lipoma (n = 2)</td>
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<td>Hematoma (n = 1)</td>
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<td>Thrombus (n = 3)</td>
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<td>Hematoma (n = 2)</td>
<td>Lipoma (n = 1)</td>
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<tr>
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<td><strong>Intracavitary (n = 2)</strong></td>
<td>Thrombus (n = 2)</td>
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<td><strong>Myocardial (n = 2)</strong></td>
<td></td>
<td>Rhabdomyoma (n = 1)</td>
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<td>Thrombus (n = 3)</td>
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<td>Vegetation (n = 1)</td>
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<td><strong>Aortic (n = 2)</strong></td>
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<td>Coronary aneurysm (n = 4)</td>
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**Table 1: Summary of cases**
**Fig. 1:** (a, b). Myxoma. A 63 year-old man asymptomatic with an echocardiogram that shows a cardiac mass. (a) Steady-State Free Precession T2-weighted image in four chambers view shows a pedunculated well-defined ovoid intracavitary mass in the right atrium with lobular contours (arrows). (b) On diastolic phase, the mass prolapses (arrowheads) through the tricuspid valve orifice.
Fig. 2: Myxoma. A 53 year-old man with dyspnea and weight loss. Contrast-enhanced CT scan shows a polypoid intracavitary left atrial mass (asterisk) that arises from the interatrial septum and protrude through the mitral valve.
**Fig. 3:** Myxoma. A 53 year-old woman with dysnea of one year of evolution. Axial T1-weighted TSE image shows an oval pediculated mass isointense respect to the miocardium. Focal area of decreased signal intensity due to calcification in the anterior part of the mass can be seen (arrowhead).
Fig. 4: Myxoma. A 69 year-old woman with dyspnea. Contrast-enhanced chest CT scan demonstrates an ovoid pediculated left atrial mass attached to the interatrial septum. The mass shows heterogeneous density, with internal foci of calcium (arrows).
Fig. 5: (a, b). Myxoma. A 65 year-old woman with a history of chest pain and palpitations. Axial unenhanced (a) and enhanced (b) T1-weighted TSE images show an oval pediculated right atrial mass with intense homogeneous enhancement (arrows).
Fig. 6: (a-d). Lipoma. A 65-year-old asymptomatic woman with history of hypertension. On transthoracic echocardiogram a left ventricular mass was found. Axial (a) and short-axis (b) T1-weighted TSE images show a small smooth hyperintense left ventricular intracavitary nodule arising from the endocardial surface of the interventricular septum (arrows). (c) On fat-suppressed T1-weighted TSE image obtained at the same level than (a), the tissue signal of the nodule is supressed (arrowhead). (d) Steady-state free precession (SSFP) image on axial view. The nodule is hyperintense and shows a hypointense peripheral halo due to chemical shift artifact (arrowhead).
**Fig. 7:** Thrombus. A 39 year old man with deep vein thrombosis. Contrast-enhanced chest CT scan shows a low-attenuation ovoid structure in the apex of left ventricle (arrow) surrounded by contrast material.
**Fig. 8:** Thrombus. A middle-aged male with a history of myocardial infarction. Four-chamber delayed-enhancement MR image shows an hypointense thrombus (arrow) surrounded by contrast-enhanced blood in the left ventricular apex. Note the transmural necrosis of the myocardium (arrowheads).
**Fig. 9**: (a, b). Tumoral thrombus. 67 year-old man with weight loss and cirrhosis. Contrast-enhanced chest CT scan obtained at arterial (a) and venous (b) phases showing an heterogeneous enhanced thrombus (arrows) extending from the inferior vena cava and suprahepatic veins to the right atrium.
**Fig. 10:** (a-c). Tumoral thrombus. 67 year-old woman with arrhythmia. On Ecocardiography a right atrial mass was seen. MRI examination was performed to characterize the mass. Axial (a) and coronal (b) TGE cine-MR images show an enlarged inferior vena cava with an hypointense mass (arrows) extending to the right atrium (arrowheads). (c) Coronal TGE T1-weighted image after administration of 0.2 mmol/Kg of Gd-DOTA demonstrates an heterogeneous mass in the lower pole of the right kidney and an heterogeneous enhanced thrombus (arrows) extending from the right renal vein through the inferior vena cava to the right atrium (arrowhead). The final diagnosis was right renal carcinoma with tumoral thrombus extending to the right atrium.
Fig. 11: Lipomatous infiltration of the interatrial septum. A 49 years old woman with uterine leiomyomatosis. Contrast-enhanced chest CT scan showing an homogeneous low attenuation (}
Fig. 12: (a, b). Lipomatous infiltration of the interatrial septum. A 57 year-old woman with cardiac arrhythmia. (a) On TSE T1-weighted image an enlarged interatrial septum (thickness, 15 mm) with hyperintense signal, preserving the oval fossa area, is seen (arrow). (b) On TSE T1-weighted image with spectral fat suppression the signal of the interatrial septum is nulled (arrowhead).

Fig. 13: (a, b). Intramural hematoma. A 74 year-old women with chest pain. (a) On non-contrast CT a well-defined oval shaped myocardial hyperdense mass in the left atrial posterior wall is seen (arrows). (b) The mass shows no contrast enhancement after intravenous material injection (black arrows).
Fig. 14: (a-c). Rhabdomyoma. A newborn male with a cardiac murmur and a left ventricular mass on echocardiogram. Axial TSE T1-weighted (a) and TSE T2-weighted images (b) show a myocardial mass in the anterior segment of the interventricular septum (arrows) with heterogeneous slightly hyperintense signal on TSE T1 and T2-weighted images. (c). Sagittal oblique T1-weighted image obtained 2 minutes following gadolinium injection showing peripheral enhancement (arrowhead).
**Fig. 15:** (a-c). Rhabdomyoma in a newborn female. Large myocardial mass (arrows) in the free wall of right ventricle with heterogeneous hyperintense signal on TSE T1-weighted (a) and TSE T2-weighted (b) images. On steady-state free precession (SSFP) image (c), the mass shows similar signal intensity to that of normal myocardium (arrowheads).

**Fig. 16:** (a, b). Lipoma in a 41 year-old man with cardiac arrhythmias. Axial TSE T1-weighted (a) and fat-suppressed images (b) show a large intracavitary right atrial mass with a signal intensity characteristic of fat on T1-weighted image (arrows) and the tissue signal dropout on fat-suppression sequence (arrowheads). Mediastinal lipomatosis can also be seen (asterisks).
Fig. 17: (a-c). Left atrial lipoma in a 79-year-old woman with palpitations. Transthoracic echocardiography showed a large left atrial mass attached to posterior wall. Diagnosis of myxoma and sessile thrombus were considered. Four-chamber (a) and sagittal (b) TSE T1-weighted images show a well-demarcated hyperintense signal mass in the posterior wall of left atrium (arrows). (c) Four-chamber fat-suppressed TSE T2-weighted image shows uniform and complete suppression of signal within the mass (arrowheads) confirming its fatty composition.
Fig. 18: (a-d). Metastases. A 56 year-old woman with renal cell carcinoma. Contrast-enhanced chest CT scan shows two myocardial masses, one in the interventricular septum (a) and the other in the inferior wall (b) both heterogeneous, with peripheral enhancement (arrows). The masses show heterogeneous signal intensity with a central hypointense area and peripheral high signal intensity (arrowheads) on TSE T1-weighted (c) and TSE T2-weighted images (d).
**Fig. 19:** (a, b). Metastasis. A 54 year-old woman with lung carcinoma. Contrast-enhanced chest CT scan shows a large necrotic mass in the inferior lung lobe (arrows). The tumor extends through the left superior pulmonary vein into the left atrium (arrowheads).
Fig. 20: (a-c). Angiosarcoma in a 77 year-old man with heart failure. On echocardiogram a cardiac mass was seen. Axial (a) and sagittal oblique (b) TGE cine-MR images show an infiltrative mass (arrowhead, arrow) involving the free wall of right ventricle and the right outflow tract. (c) Delayed T1-weighted image obtained 5 minutes following gadolinium injection showing heterogenous enhancement (arrow).
Fig. 21: (a-c). Leiomyosarcoma. A 57 year-old man with atrial fibrillation and syncope. (a) Contrast-enhanced chest CT scan showing a broad based infiltrative mass along the interatrial septum which occupies almost the left atrial chamber (arrows). (b, c) Follow-up contrast CT scan one year after complete surgical resection shows a left atrial mass (arrows) and a large right pleural effusion.
Fig. 22: (a, b). Caseous degeneration of the mitral annulus. A 73 year-old asymptomatic woman with a left atrial mass on echocardiogram. Steady state free precession T2-weighted image in four chambers (a) and two chambers (b) view show a well-defined hypointense mass located at the posterior mitral leaflet (arrowheads).
Fig. 23: (a-d). Caseous degeneration of the tricuspid annulus. A 72 year-old woman with heart failure. During a coronary catheterization a calcified not-vascularized mass was detected. (a) Chest radiograph shows an annular round-shape calcification projected on the cardiac silhouette (arrows). (b) CT scan demonstrates an hypodense well-defined mass with a peripheral calcification in the atrioventricular groove (arrowhead). (c, d) Steady-state free precession (SSFP) cineMR in four and two chambers view show a mass in the atrioventricular groove, with heterogeneous signal due to
calcification (arrowheads). The mass showed no enhancement after intravenous contrast administration (not shown).

Fig. 24: (a-c). Pericardial cyst in a 69 year-old man with hypertrophic myocardiopathy. On echocardiography a mass was seen behind the lateral left ventricle wall. (a, b) Steady-state free precession (SSFP) images show an oval well-defined pericardial mass with homogeneous high signal intensity (arrow). (c) Four-chamber delayed-enhancement MR image showing the non-enhanced pericardial mass (arrowheads).
**Fig. 25**: Pericardial loculated effusion. A 73 year-old woman presented at emergency room with heart failure. On transthoracic ecocardiogram a large pericardial effusion was seen and a mass over the right ventricle was suspected. Contrast enhanced CT scan shows a loculated pericardial fluid with peripheral enhancement (arrows). Epicardial fat (asterisk) between loculated pericardial fluid and the free wall of right ventricle can be seen.
**Fig. 26:** Pericardial loculated effusion. A 61 years-old man with dyspnea and cardiac tamponade. Contrast-enhanced CT scan shows a loculated pericardial fluid collection (asterisks) with attenuation close to that of water and bilateral pleural effusions.
Fig. 27: Pericardial tuberculosis. A 76 year-old man with heart transplantation 12 years ago, presented with clinical history of weight loss and fever. Contrast-enhanced CT scan demonstrates diffuse pericardial thickening and an enhanced mass with central low attenuation surrounding the right coronary artery (arrowhead).
Fig. 28: (a-d). Giant right coronary aneurysm. A 42 years-old woman with two months history of dyspnea and chest pain. (a) Unenhanced CT scan shows rounded mediastinal mass similar density of heart chambers (asterisk) and small peripheral linear calcifications (arrowheads) which compress heart to left side. (b) CT angiogram obtained after injection of contrast material shows homogeneous enhanced mass (asterisk), with similar degree of enhancement as heart chambers. (c, d) Sagittal oblique MIP (c) and volume-rendered (d) images obtained from 3D angio-RM show the giant right coronary artery aneurysm (asterisks). Surgery of aneurism exclusion and right coronary reimplantation was performed.
Fig. 29: (a, b). Right artery coronary aneurysm with spontaneous dissection. A 55 year-old man with chest pain and myocardium infarct. Axial TSE T1-weighted (a) and TSE T2-weighted (b) images showing a well-defined hyperintense right coronary artery aneurysm in the right atrioventricular groove (arrows) with an hypointense convex line related to dissection (arrowheads).
Fig. 30: (a, b). Valsalva sinus aneurysm. A 69 year-old man with arterial hypertension. (a) Volume-rendered angio-MR image demonstrates a right Valsalva aneurysm (blue). (b) Contrast-enhanced CT scan after surgery showing the excluded Valsalva sinus aneurysm as a well-circumscribed mass of homogeneous low attenuation (asterisk).
Fig. 31: (a-d). Mediastinal lymphangioma. An asymptomatic newborn girl was admitted for evaluation of a lung lesion. (a) Chest radiograph showed bilateral paraspinal bulging lines (arrows). (b) Sagittal and (c) axial T1-weighted images show a large homogeneous
mass of low signal intensity that infiltrates the wall of the left atrium with extension to the retrocrural space (arrows). (d) On axial T2-weighted image the mediastinal mass is homogeneous and has very high signal intensity (arrow).

Fig. 32: (a-c). Pericardic paraganglioma. A 39 years-old woman with recurrent episodes of epigastric pain after social consumption of alcoholic beverages and high plasma noradrenaline levels. (a). Axial TSE T1-weighted and (b) coronal TSE T2-weighted images show a mass compressing the posterior right atrial wall with heterogeneous signal intensity and multiple serpentine and punctate areas of signal void (arrows). (c) First-pass perfusion MR image showing intense heterogeneous enhancement (arrows).
**Fig. 33:** Pericardial metastasis. A 73 year-old woman with past history of follicular thyroid carcinoma 30 years ago. Enhanced-CT scan shows a pericardial mass with thick peripheral enhancement (arrows) and a low-attenuation central area related to necrosis.
Fig. 34: (a-c). Mediastinal lymphoma. A 14 years-old girl with astenia and chest pain. Axial (a, b) and sagittal (c) TSE T1-weighted images show a large anterior mediastinal mass infiltrating the pericardium (asterisks).
Conclusion

Cardiac tumors pose a diagnostic challenge. Echocardiography, MRI and CT play an important role in imaging these tumors.

The majority of tumors that are found in or adjacent to the heart are metastasis from the lung, breast or from haematologic malignancies.

Primary cardiac tumors are much less common than metastatic cardiac tumors. Primary tumors can be either benign or malignant, being the former more frequent.

The diagnostic considerations can be significantly simplified if one has accurately localized the lesion. Following localization, evaluation of the signal characteristics of the lesion is of paramount importance, as many lesions have nearly pathognomonic features (e.g. tumors composed of fat).

The contrast enhancement pattern also can be quite helpful; for instance, myxomas and thrombi can have similar location, but myxomas demonstrate heterogenous enhancement while thrombi, by virtue of being avascular, have no enhancement.

References


**Personal Information**

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