Received: 15 July 2017 | Accepted: 23 August 2017

DOI: 10.1002/joa3.12030

SPECIAL ISSUE: RISK STRATIFICATION AND SPECIFIC MANAGEMENT

WILEY Journal of Arrhythmia Open Access

Clinical presentations, diagnosis, and management of arrhythmias associated with cardiac tumors

Jayaprakash Shenthar MD, DM, FACC, FRCP (London)[1]

[1]Electrophysiology Unit, Department of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bangalore, India

Correspondence
Prof. Jayaprakash Shenthar, Electrophysiology Unit, Department of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bangalore, India.
Email: jshenthar@yahoo.com

Abstract

Cardiac tumors are a rare cause of arrhythmias in clinical practice. They can cause a broad spectrum of arrhythmias, from low-grade ectopics to incessant ventricular tachycardias, including sudden cardiac arrest. Both primary and secondary cardiac tumors can produce arrhythmias, but not all tumors cause arrhythmias. Although cardiac tumors can cause arrhythmias in fetuses and older adults alike, only specific cardiac tumors are the underlying cause of arrhythmia in different age groups. This article reviews various cardiac tumors that are associated with arrhythmias, their clinical presentations, diagnostic features, and management.

KEYWORDS

arrhythmias, cardiac tumors, incessant tachycardias, pediatric arrhythmias, sudden death

1 | INTRODUCTION

Cardiac tumors are rare cardiac disorders, and they occur either as primary tumors of the heart or as secondary cardiac tumors due to metastasis from elsewhere. Before the advent of cardiac surgery, cardiac tumors were a mere curiosity usually diagnosed at autopsy, and the diagnosis was academic since the outlook was dismal. With the advent of advanced imaging techniques such as echocardiography, computed tomography (CT), and magnetic resonance imaging (MRI), it has become possible to diagnose cardiac tumors at an early stage. Surgical resection of cardiac tumors is feasible owing to advances in cardiac surgical techniques including cardiopulmonary bypass.[1,2] Cardiac tumors have diverse clinical presentations and are known to be great mimickers.[3] The clinical manifestations of cardiac tumors are due to their mass effect, local invasion, embolization, or constitutional symptoms.[4] Tumor invasion results in conduction system abnormalities, supraventricular and ventricular arrhythmias, or sudden death.[2,4] It is important to recognize the presence of a cardiac tumor as the underlying cause of arrhythmia because in many cases surgical resection cures the rhythm abnormality.[2,5]

2 | EPIDEMIOLOGY

Primary cardiac tumors are rare, with an incidence of 0.0017%-0.19% in unselected patients at autopsy.[6] Three-quarters of primary tumors are benign, of which nearly half are myxomas, and the rest include lipomas, papillary fibroelastoma, and rhabdomyomas. Less common tumors are fibromas, hemangiomas, teratomas, and mesotheliomas of the atrioventricular (AV) node. Granular cell tumors, neurofibromas, and lymphangiomas are very rare.[7] Whereas rhabdomyomas are the most common primary tumors of the heart in children, myxomas are more common in adults.[6] In a series of children with a cardiac tumor who underwent surgery, 24% had clinically significant cardiac arrhythmias.[2] Primary cardiac tumors contribute to a small percentage ($\sim$0.0025%) of sudden deaths, and a majority (86%) of the primary cardiac tumors that cause sudden cardiac death are benign. Cystic tumor of the AV node that is a benign tumor is the most common cause of sudden death.[4] Secondary cardiac tumors are 100-1000 times more common than primary cardiac tumors, and they occur in the setting of underlying systemic malignancy.[5] In the majority of patients with systemic malignancy, cardiac metastases are usually silent, and even in those with

symptoms, consequences of heart metastasis are often mistaken for elements of general health deterioration.[8]

3 | CLASSIFICATION OF CARDIAC TUMORS

According to the 2015 World Health Organization classification, cardiac tumors are classified as (i) benign tumors or tumor-like conditions, (ii) tumors of uncertain biologic behavior, (iii) germ cell tumors, (iv) malignant tumors, and (v) tumors of the pericardium[9] (Table 1). A hamartoma is a benign tumor-like malformation composed of an abnormal mixture of cells and tissues and is found in areas of the body where growth occurs. Though a hamartoma resembles a neoplasm, it does not show any tendency to evolve into one, and hence, it is considered a developmental error. Uncomplicated hamartomas do not tend to grow, except as determined by the normal growth controls of the body. It is often difficult to differentiate between a hamartoma and a benign neoplasm since both lesions can be clonal. Hamartomas have relatively normal cellular differentiation, but the architecture of the tissue is disorganized and is the result of an abnormal formation of normal tissue. They grow at the same rate as the tissue of the organ from which they arise and rarely invade or compress surrounding structures significantly. A benign tumor is a mass of cells that do not invade neighboring tissue or metastasize and has a low growth rate. A benign tumor is typically surrounded by an outer fibrous sheath or remains within the epithelium. Benign neoplasms are typically but not always composed of cells that bear a strong resemblance to a normal cell of their organ of origin.

TABLE 1 The 2015 World Health Organization classification of tumors of the heart[9]

Type of tumor
Benign tumors and tumor-like conditions
Rhabdomyoma
Histiocytoid cardiomyopathy/Purkinje cell hamartoma/cardiac hamartoma
Hamartoma of mature cardiac myocytes
Adult cellular rhabdomyoma
Cardiac myxoma
Papillary fibroelastoma
Hemangioma (capillary, cavernous, arteriovenous, intramuscular)
Cardiac fibroma lipoma
Cystic tumor of the atrioventricular node
Granular cell tumor
Schwannoma
Tumors of uncertain biologic behavior
Inflammatory myofibroblastic tumor
Paraganglioma
Germ cell tumors
Teratoma
Mature teratoma
Immature yolk sac tumor
Malignant tumors
Angiosarcoma
Undifferentiated pleomorphic sarcoma
Osteosarcoma
Myxofibrosarcoma
Leiomyosarcoma
Rhabdomyosarcoma
Synovial sarcoma
Miscellaneous sarcomas
Cardiac lymphomas
Metastatic tumors
Tumors of the pericardium
Benign
Solitary fibrous tumor
Malignant
Angiosarcoma
Synovial sarcoma
Malignant mesothelioma
Germ cell tumors
Teratoma, mature
Teratoma, immature
Yolk sac tumor

4 | TYPES OF ARRHYTHMIAS IN CARDIAC TUMORS

Cardiac tumors produce a wide variety of arrhythmias dependent on the particular tumor type and the site of involvement. Although both benign and malignant cardiac tumors cause abnormalities of heart rhythm, not all tumors produce arrhythmias. The arrhythmias resulting from cardiac tumors include atrial ectopics, atrial tachycardias, atrial flutter, atrial fibrillation, Wolff-Parkinson-White syndrome, ventricular ectopics, ventricular tachycardia (VT), torsades de pointes, AV blocks, and sudden death.[2,4,10] Arrhythmias associated with cardiac tumors are more often incessant, especially in younger children, and the mechanism can be reentry or triggered automaticity.[2,5] Primary cardiac tumors can afflict patient of all ages, with certain tumors being more common in infancy and childhood while others more often seen in adults (Table 2).

5 | SPECIFIC CARDIAC TUMORS CAUSING ARRHYTHMIAS

5.1 | Tumors common in infants, children, and young adults

Intractable arrhythmia, especially in pediatric age, should trigger a search for cardiac tumor as the underlying cause.[5] It is important to recognize the type of cardiac tumor causing the arrhythmia because management approaches differ. Certain tumors, such as rhabdomyomas, may not require treatment as they tend to regress, whereas fibromas require surgical excision (Table 3).

TABLE 2 Incidence of primary cardiac tumors by mean age at presentation[12]

Tumor type	%	Mean age at presentation
Rhabdomyoma	2	33 wk
Histiocytoid cardiomyopathy	<1	10.5 mo
Fibroma	2	13 y
Hemangioma	1	31 y
Cystic tumors of AV node	<1	38 y
Myxoma	76	50 y
Lipoma	8.4	50 y
Primary lymphoma	1-2	50 y
Lipomatous hypertrophy of the atrial septum	2.2	70 y

AV, atrioventricular.

TABLE 3 Tumors causing arrhythmias in children[2,5,9,14]

Type of tumor	Arrhythmia	Location
Rhabdomyoma	VT, WPW, atrial and ventricular ectopics, atrial and ventricular tachycardias, AV block	Ventricular endocardium commonly. One-third in the atrium
Fibroma	SCA, VT (incessant, sustained, nonsustained)	Ventricles or ventricular septum. Occasionally atrium
Histiocytoid cardiomyopathy	SCA, incessant VT, WPW	Ventricles
Cystic tumor of AV node	SCA, AV blocks	AV node
Hemangioma	SCA,	Ventricles
Myxoma	Ventricular tachycardia	Atrium. Occasionally ventricles

AV, atrioventricular; VT, ventricular tachycardia; WPW, Wolff-Parkinson-White syndrome; SCA, sudden cardiac arrest.

5.1.1 | Rhabdomyoma

Rhabdomyoma is a hamartoma that occurs in fetuses, infants, and children and accounts for about 60% of cardiac tumors in pediatric patients and 2% of all primary cardiac tumors across all age groups.[2,11] It has no gender predilection, and the diagnosis is made from before birth to 6 years of age, with a mean age at diagnosis of 33 weeks.[12] Approximately 40% of rhabdomyomas are diagnosed by fetal ultrasound, and about half manifest within 6 months after birth by producing hemodynamic obstruction or ventricular arrhythmias, while the rest are diagnosed during the evaluation for tuberous sclerosis.[2,10] As many as 80%-90% of patients diagnosed with rhabdomyomas have tuberous sclerosis or a family history.[9,11] Histologically, cardiac rhabdomyomas consist of nodules of rounded myocytes with large vacuoles secondary to intracytoplasmic accumulation of glycogen and intervening strands of myocyte cytoplasm.[9]

Location

The most frequent site of occurrence of rhabdomyoma is the ventricular myocardium, with occasional protrusion into the cavity. In contrast to cardiac fibromas, rhabdomyomas do not calcify. Rhabdomyomas are small, with diameters of 2-20 mm, and in more than 90% of cases are present in both the left and right ventricles, especially in patients with tuberous sclerosis.[9] Approximately a third of rhabdomyomas also involve either one or both atria.[10]

Arrhythmias

A third of patients with cardiac rhabdomyoma have some form of arrhythmia, and 16% have clinically significant arrhythmias.[2] Ventricular tachycardia is the most common arrhythmia and usually presents in infancy and childhood. Other arrhythmias that are seen in patients with rhabdomyomas are, manifest pre-excitation with or without supraventricular tachycardia (SVT), which is caused by concealed accessory pathways, and ectopic atrial tachycardias. Pre-excitation has been reported in 80% of fetuses with rhabdomyoma using fetal magnetocardiography, and it persists in 50% at birth. The prevalence of pre-excitation implies that tumors affect the AV groove and effectively form an accessory connection.[13] Low-grade arrhythmias, such as frequent ventricular ectopic beats or couplets and brief nonsustained SVT, are observed in 12% of patients with rhabdomyoma.[2] Rhabdomyoma of the AV junction causes AV conduction abnormalities.[14]

Diagnosis

Fetal ultrasound is the most common diagnostic modality used for the diagnosis of cardiac rhabdomyoma in utero. Fetal magnetocardiography, if available, is complementary to ultrasound for rhythm assessment in a fetus with cardiac rhabdomyoma.[13] On ultrasound, rhabdomyomas appear as well-circumscribed, intramural nodules observed as homogeneous and hyperechogenic mass.[15] Rhabdomyomas are isointense to marginally hyperintense relative to myocardium on T1-weighted images, hyperintense on T2-weighted images, and hypointense relative to myocardium after contrast material administration on MRI.[16]

Treatment

Patients with hemodynamically stable VTs or SVTs respond to antiarrhythmic therapy with propranolol or sotalol, with the resolution of the arrhythmia as the tumor regresses. Patients with recurrent or intractable VT and large tumors need surgical excision, which results in a successful elimination of VT. Catheter ablation is curative for patients with SVT with or without pre-excitation not controlled medication. Antiarrhythmic therapy suppresses ectopic atrial tachycardias, and the arrhythmias tend to resolve over time. Low-grade arrhythmias do not require any treatment.[2]

5.1.2 | Histiocytoid cardiomyopathy

Histiocytoid cardiomyopathy is also known as oncocytic cardiomyopathy, purkinje cell tumor/hamartoma, or simply cardiac hamartoma.[9] These rare (about 150 cases in the literature) benign tumors

present with incessant tachycardia or sudden cardiac arrest. The age of presentation varies from birth to 30 months (mean: 10.5 months), with some patients presenting with intrauterine tachycardia. Most patients have incessant tachycardia for about 4.7 months before presentation. Incessant VT due to this tumor has not been reported after the age of 3 years. Nearly 50% of symptomatic patients present with cardiac arrest and one-fourth with tachycardia-induced heart failure. Administration of digoxin and verapamil and presence of fever are risk factors for sudden cardiac arrest.[5] Histiocytoid cardiomyopathy consists of a multifocal hamartomatous collection of cells that resemble modified myocytes of the conduction system. More than one-third of children have additional cardiac and extracardiac anomalies, of which about 5% are familial. Recently, a novel mutation in the NADH: ubiquinone oxidoreductase subunit B11 gene (NDUFB11) has been identified in a few probands by direct sequencing, suggesting a role in the pathogenesis of the disease.[9]

Location

Histiocytoid cardiomyopathy is found as small flat sheets of cells with an area of about 1 cm^2 on the epicardial or endocardial surfaces of the left ventricle in 85% of cases and right ventricle in the remainder.[5] On gross examination, the tumor is gray-white and, on histology, it consists of round to polygonal cells up to twice the size of adjacent myocardial cells with distinct cytoplasmic borders and variable amounts of fine to coarse eosinophilic granules in the cytoplasm. The nuclei are large and hyperchromatic, with a prominent nucleolus and no mitotic figures, and the cells display a marked proliferation of mitochondria, remnants of sarcomeres, and variable amounts of lipid and glycogen.[5,9]

Arrhythmias

Most patients present with incessant VT with a mean rate of 260 beats/min (range: 167-440) and a mean QRS duration of 0.08 seconds (range: 0.06-0.11 seconds). Depending on the chamber of origin, the most common tachycardia configuration is right bundle branch block in 80% of cases (left ventricular) and left bundle branch block in 20% (right ventricular).[5]

Diagnosis

Since these tumors occupy only small regions on or within the heart, imaging modalities such as echocardiography, CT, and MRI are not useful in their detection. Electrophysiological studies help to locate the origin of the VT as well as elucidate its mechanism.[11]

Treatment

Ventricular tachycardia associated with histiocytoid cardiomyopathy is resistant to most antiarrhythmic drugs, including lidocaine, procainamide, quinidine, propranolol, digoxin, verapamil, amiodarone, phenytoin, mexiletine, and propafenone.[5,11] Treatment with intravenous digoxin and verapamil should be avoided as it can precipitate sudden cardiac arrest. Surgical excision results in cure of the arrhythmia.[5]

5.1.3 | Fibroma

Fibroma is the second most common cardiac tumor in infants and children.[10] Cardiac fibroma is a congenital benign neoplasm that typically affects children, a third of whom are younger than 1 year at presentation. It is the most commonly resected cardiac tumor in children. The mean age of presentation is 13 years, and the tumor has no gender or race predilection.[3] Arrhythmia, the most common presenting symptom of fibroma, is present in up to a third of patients.[2]

Location

Fibromas are usually solitary and occur predominantly in the ventricles or ventricular septum, most often arising from within the myocardium. The most common areas are the left ventricular free wall, anterior free wall, and ventricular septum.[11,15]

Arrhythmias

Clinically significant arrhythmias are more common in fibroma than in any other cardiac tumors. Some form of cardiac arrhythmia is present in 64% of cases, and VT and sudden death may occur in up to 30% of patients.[2,10] The mechanism of VT is consistent with reentry because the tachycardia has monomorphic and regular morphology, is inducible and terminable with pacing maneuvers, and can be successfully terminated by electrical cardioversion. Some patients demonstrate multiple VT morphologies or polymorphic VT, which is explained by different exit points from the reentrant circuit, although triggered automaticity cannot be dismissed.[2]

Diagnosis

Baseline ECG in the majority of fibroma patients demonstrates T-wave abnormalities, and VT morphologies on ECG are consistent with an origin near the tumor site.[2] On the echocardiogram, they usually appear as a distinct, well-demarcated, noncontractile, and highly echogenic mass within the myocardium, with frequent extension into the cavity.[15] They are isointense or hypointense on T1-weighted images and homogeneously hypointense on T2-weighted images. Administration of gadolinium contrast material can result in different patterns of appearance, including no enhancement and enhanced or isointense rim with a hypointense core, which reflects reduced vascularity.[16]

Treatment

Surgical resection is the treatment of choice for patients with fibroma presenting with VT, and it can successfully eliminate the VT in all cases. Without surgery, the size of the fibroma decreases in some patients along with somatic growth, but, unlike rhabdomyomas, fibromas never resolve completely over time.[2]

5.1.4 | Hemangioma

Hemangioma is a benign vascular tumor that represents <2% of all cardiac tumors and can grow to a considerable size.[3,11] Cardiac

hemangioma is rare, with occasional presentation at birth or in childhood and more common in adulthood.[9] The mean age at diagnosis is 31 years, and it is more frequent in men than in women.[3,12] Cardiac hemangiomas are of 2 primary histopathological types: (i) circumscribed and histologically uniform, with cavernous vascular spaces that often have a myxoid background, and (ii) infiltrating, with dysplastic arteries infiltrating the myocardium and with regions of capillary hemangioma and fat infiltrates.[3]

Location

Hemangiomas can arise from the epicardium and myocardium and also protrude into the cardiac cavities.[3] The common location of this tumor is the lateral wall of the left ventricle or the anterior wall of the right ventricle.[10]

Arrhythmias

Hemangiomas are rare in children, with sudden cardiac arrest being the only clinically significant rhythm event.[2] Hemangiomas in adults have been associated with atrial fibrillation,[17] frequent ventricular ectopics,[18] and intractable VT.[19]

Diagnosis

On the echocardiogram, hemangiomas appear as an echogenic mass with echo-lucencies located within the endocardium, myocardium, epicardium, or pericardium. They are commonly situated in the right ventricular free wall or the left ventricular lateral wall.[15] On MRI imaging, hemangiomas are isointense compared to myocardium on T1-weighted images, hyperintense on T2-weighted images, and are strongly enhanced by contrast medium, resulting in inhomogeneous appearance because of interspersed calcification and fibrous septae within the masses.[20]

Treatment

The unpredictable long-term behavior of these tumors mandates resection, during which it is essential to ligate all vascular branches since failure to do so will result in bleeding.[11] Even if complete surgical resection is not possible, prognosis for this tumor is favorable because of spontaneous regression.[10]

5.1.5 | Cystic tumor of AV node

Cystic tumor of the AV node is an extremely rare benign congenital cystic mass. It is also known as mesothelioma of the AV node, congenital polycystic tumor of the AV node, and intracardiac endodermal heterotopia.[9] Though cystic tumors can present at any age (11 months to 89 years), the mean age at presentation is 38 years, with a female-to-male ratio of 3 to 1. Histologically, the cyst wall is composed of fibrous connective tissue with foci of chronic inflammation covered by a single layer of cuboidal epithelioid cells. Within the interstitial fibrous tissue are smaller cysts lined by similar cuboidal cells and containing hyaline eosinophilic material.[3]

Location

The cystic tumor is 2-20 mm in diameter and is usually located at the base of the atrial septum near the AV node in the triangle of Koch.[3]

Arrhythmias

More than 60% of patients with cystic tumor of the AV node present with complete AV block, but the main danger is in the high propensity of sudden death. Cystic tumor of the AV node is the smallest and most common tumor that can lead to sudden unexpected death.[4]

Diagnosis

The majority of cystic tumors are diagnosed at the time of autopsy in individuals who have died suddenly.[3] A sufficiently large cystic tumor of the AV node can be detected by echocardiography.[11] This tumor is sometimes encountered during cardiac surgery for another cause.[11]

Treatment

If heart block is the presenting symptom of a cystic tumor of the AV node, a permanent pacemaker should be implanted.[10] Owing to the benign nature of the tumor itself, the decision to resect needs to be individualized. A cystic tumor detected on imaging in an asymptomatic patient warrants close monitoring to identify AV conduction abnormalities. Patients presenting with AV blocks require pacemaker implantation. If this tumor is encountered during cardiac surgery for another cause, resection should be considered to prevent sudden death with the expectation that surgery is likely to induce AV block necessitating pacemaker implantation.[11]

5.2 | Tumors common in older adults

Certain tumors are more common in adults, with some tumor-like conditions such as lipomatous hypertrophy of the atrial septum occurring exclusively at older age (Table 4).

5.2.1 | Cardiac myxoma

Myxomas, the most common cardiac tumors, constitute nearly half of benign heart tumors. Myxoma occurs in all age groups but is particularly frequent between the third and sixth decades of life (mean: 53 years), with the youngest known victim a stillborn infant and the oldest patient a 95-year-old woman.[6] Myxomas as a manifestation of Carney complex are seen in 5% of patients, who are younger and have multiple or unusually located tumors, with a higher incidence of embolic episodes. Despite being by far the most common primary heart tumors, myxomas are rare in children.[21] Myxomas consist of a myxoid matrix composed of an acid mucopolysaccharide-rich stroma.[6] Histologically, myxomas have soft, gelatinous, or myxoid regions with some cystic areas that show hemorrhage, whereas other parts are firmer and show abundant

TABLE 4 Tumors causing arrhythmias in adults

Type of tumor	Arrhythmia	Location
Myxoma	Atrial arrhythmias, ventricular tachycardia, torsades de pointes	Atrium. Occasionally ventricles
Lipomatous hypertrophy of the atrial septum	Atrial arrhythmias, sinus node dysfunction, AV blocks	Interatrial septum
Lipoma	Ventricular tachycardia, sudden death, conduction system abnormalities	Left ventricles and right atrium
Lymphoma	Atrial fibrillation, AV blocks	Commonly right atrium
Secondary tumors	Atrial tachycardia, atrial fibrillation	Any location

AV, atrioventricular.

mature collagen. Calcification and ossification are seen in 10% of myxomas. Histological diagnosis of cardiac myxoma depends on identification of myxoma cells, which have occasionally been called lepidic cells.[3]

Location

Myxomas are endocardial and project into the heart chamber cavity. They arise from the left atrial septum in 85%, right atrial septum in 11%, and left and right ventricles in 3%-4% of patients.[6,9] Most myxomas have a broad base, and few have a narrow pedicle, which is characteristically attached to the interatrial septum.[3] Tumors range from 1 to 15 cm in diameter, with most being between 5 and 6 cm.[6]

Arrhythmias

Arrhythmias are uncommon with myxomas, and atrial fibrillation may develop in about 15% of cases of left atrial myxoma.[10] A single case of syncope due to torsades de pointes with prolonged QT interval in a 38-year-old woman with left ventricular myxoma has been reported.[22] Repetitive monomorphic VT as the first manifestation of a right ventricular myxoma has also been reported.[23]

Diagnosis

Among the noninvasive diagnostic tools, echocardiography (including transesophageal echocardiography), CT, and MRI are of primary importance. On echocardiography, cardiac myxomas typically appear as a heterogeneous mobile mass attached to the endocardial surface of the fossa ovalis by a stalk.[15] Myxomas usually have heterogeneous low attenuation, with calcification frequently seen on CT.[24] On MRI imaging, myxomas demonstrate heterogeneous signal intensity and are isointense relative to the myocardium on T1-weighted images, hyperintense on T2-weighted images, and show heterogeneous contrast enhancement. Myxomas have a heterogeneous pattern of enhancement following administration of gadolinium contrast material. Less commonly myxomas are heterogeneous on both T1- and T2-weighted images because of calcification, hemorrhage, or necrosis.[16,20]

Treatment

The treatment of choice for myxomas is surgical resection, which is usually curative, with about a 1% chance of recurrence.[6,9] Both torsades de pointes due to a left ventricular myxoma and repetitive monomorphic VT due to a right ventricular myxoma have been cured by surgical resection of the tumor, indicating that myxoma was the cause of the arrhythmias.[22,23]

5.2.2 | Cardiac lipoma

True lipomas of the heart are rare benign neoplasms, comprising <0.5% of excised tumors. Most lipomas are clinically silent and found incidentally on imaging or at autopsy.[9] Lipomas can occur at any age, typically in the fifth and sixth decades of life, and affect both genders equally. Lipomas account for 10% of all primary cardiac tumors and 14% of benign cardiac tumors.[25]

Location

Lipomas are usually encapsulated, homogeneous fatty tumors, but can occasionally be infiltrating.[24,26] Cardiac lipomas can originate from the subendocardium (approximately 50%), subpericardium (25%), or myocardium (25%) and are located more frequently in the left ventricle or right atrium.[25]

Arrhythmias

Arrhythmias are infrequent, but location within the myocardium can cause ventricular arrhythmia or conduction disturbance. Ventricular tachycardia (Figures 1-3) and sudden death are rare manifestations of cardiac lipoma.[10,26,27]

Diagnosis

The echocardiographic appearance of lipomas varies with their location, being hyperechoic in the cavity but hypoechoic in the pericardium and is homogenous without evidence of calcification.[15] Cardiac lipomas appear as homogeneous, low-attenuation masses either in a cardiac chamber or the pericardial space on CT. On MRI imaging, lipomas have homogeneously increased signal intensity on T1-weighted images that decreases in fat-saturated sequences.[24]

Treatment

Surgical resection is usually necessary for symptomatic cardiac lipomas, and it usually results in a cure of the arrhythmia.[26] Even in asymptomatic patients, surgical excision should be considered because of the tendency for progressive growth.

5.2.3 | Lipomatous hypertrophy of the atrial septum

Lipomatous hypertrophy of the atrial septum is a rare benign entity that is characterized by excessive deposition of fat in the interatrial septum and a thickness of >2 cm.[28] Lipomatous hypertrophy of the atrial septum results from adipose-cell hyperplasia of the interatrial septum.[3] The reported incidence of this anomaly varies (1% at

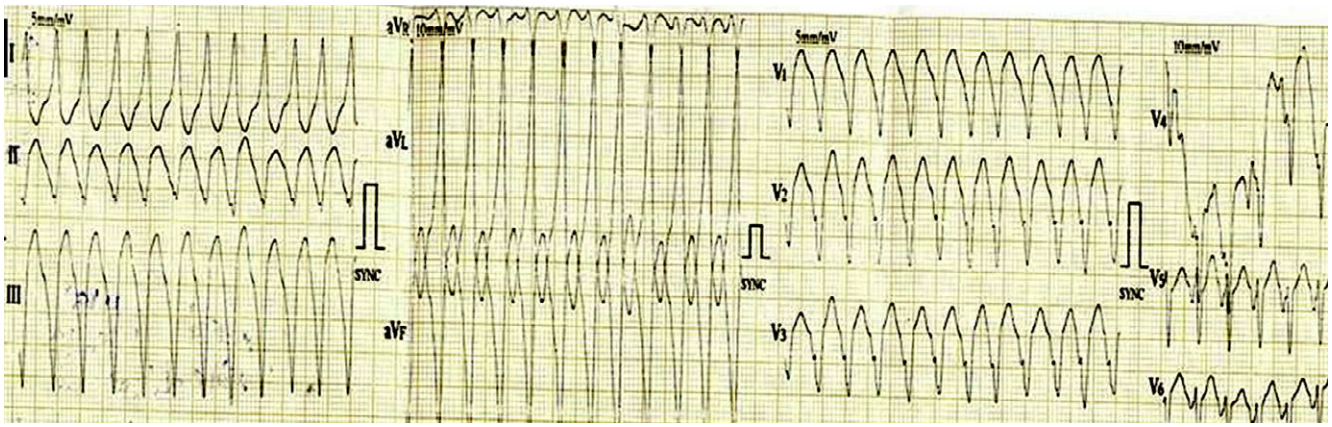

FIGURE 1 A 12-lead electrocardiogram of a 25-year-old man with palpitations and presyncope shows a left bundle branch morphology left axis ventricular tachycardia at a rate of 215 beats per minute

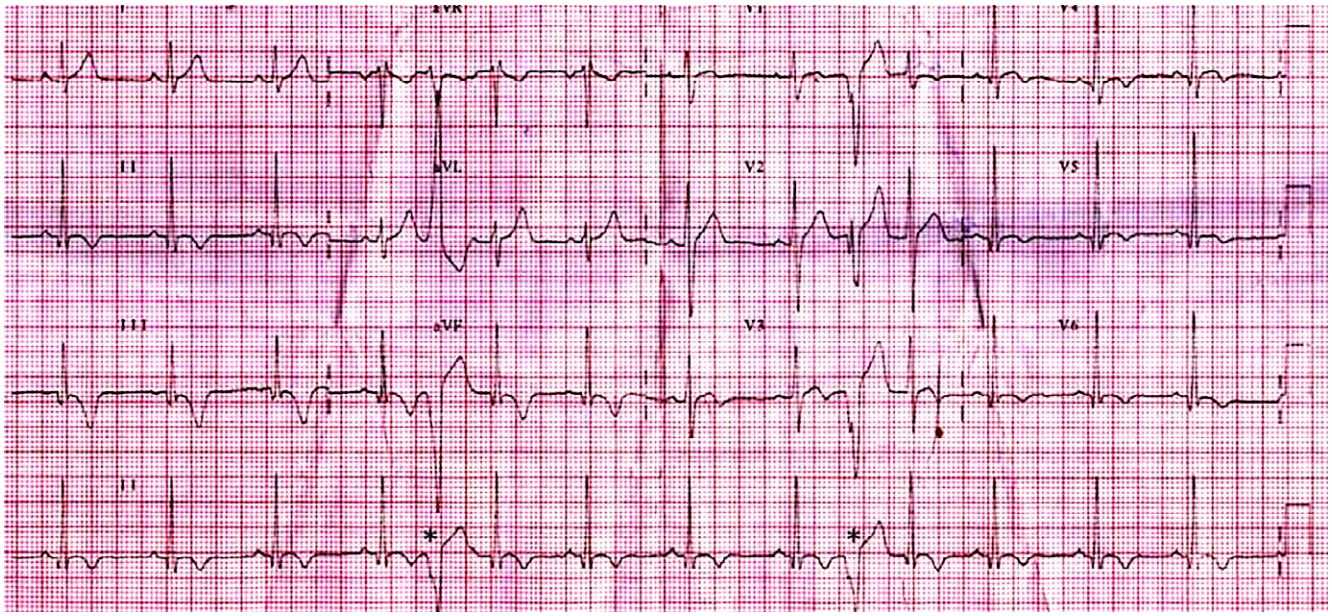

FIGURE 2 A 12-lead electrocardiogram of the same patient as in Figure 1 in sinus rhythm shows monomorphic ventricular ectopics with a morphology similar of that of VT (* in rhythm strip). T inversion in inferolateral leads is also noted. LBBB, left bundle branch block; VT, ventricular tachycardia

autopsy, 8% on transthoracic echocardiography, and 2.2% in a prospective study). It is associated with obesity and advanced age, with a slight female preponderance. The mean age at presentation is 70 years (range: 57-87 years), and about 40% of patients have a BMI of >30.[29] Histologically, lipomatous hypertrophy is composed of brown fat and cardiac myocytes, and hence it is considered a form of hamartoma or hyperplasia. Lipomatous hypertrophy is often an incidental finding on imaging.[9]

Location

Lipomatous hypertrophy of the atrial septum has characteristic features in imaging studies. Hypertrophy occurs in the upper and lower parts of the interatrial septum and typically spares the foramen ovale, which gives the lesion a distinctive dumbbell shape.[29]

Arrhythmias

Lipomatous hypertrophy of the atrial septum is associated with a variety of atrial arrhythmias in >60% patients, such as frequent premature atrial complexes, multifocal atrial tachycardia, wandering atrial pacemaker, atrial fibrillation, sick sinus syndrome, and sudden death.[10,28,29] Malignant cardiac arrhythmias occur as a result of extensive bleeding into the lesion.[29]

Diagnosis

Echocardiographic diagnosis is based on the characteristic bilobed or dumbbell-shaped atrial septum, with a thickness posterosuperiorly and anteroinferiorly to the valve of the fossa ovalis of 15 mm or more in the absence of other causes.[30] CT imaging reveals a homogenous mass of fat attenuation with sharp margins sparing the

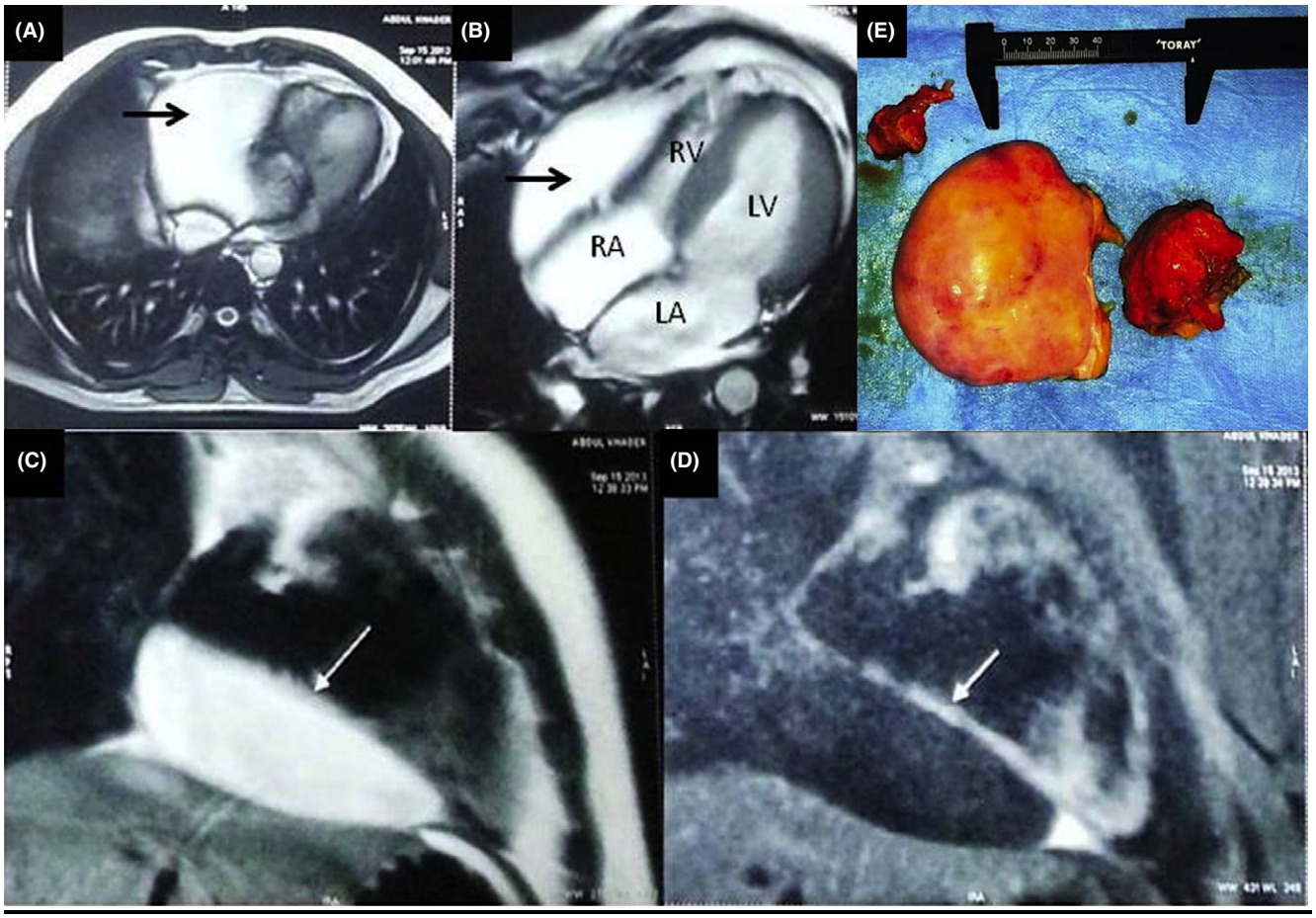

FIGURE 3 Cardiac magnetic resonance imaging: A, B, T1-weighted images reveal a circumscribed hyperintense mass located subepicardially to the lateral and inferior aspects of the RA and RV. C, D, A comparison of a T1 image (C) and a fat suppression sequence (D) of the subepicardial mass in the same view. The radiolucent appearance of the mass in the subepicardial location in fat-suppressed sequences suggests a lipoma. E, Gross appearance of the excised tumor shows a large circumscribed, encapsulated, bilobed tumor measuring 10 × 10 × 9 cm with an intervening stalk. RA, right atrium; RV, right ventricle. (From Ref. 26 with permission)

fossa ovalis, resulting in a prominent central constriction giving the lesion a distinct shape with no contrast enhancement.[29] MRI imaging also reveals a typical dumbbell shape with homogeneously increased signal intensity on T1-weighted images.[24]

Treatment

Management consists of treatment of underlying arrhythmias with antiarrhythmic drugs or implantation of a pacemaker in cases with conduction abnormalities. The indications for surgery are somewhat controversial, as incidental detection of mass may lead to unnecessary surgery for a benign lesion.[12]

5.2.4 | Cardiac Lymphoma

Primary cardiac lymphomas of the heart are rare primary malignant tumors of the heart accounting for 1%-2% of all surgically resected heart tumors.[9] The 2 defining features of primary cardiac lymphoma are, the absence of systemic lymphoma and the presence of the bulk of the neoplasm within the pericardium causing cardiac symptoms.[3]

Primary cardiac lymphomas usually occur after the fifth decade of life and are exceedingly rare in children. They have a marked male predominance in AIDS patients.[31] Morphologically, the lymphomas appear as multiple, firm, whitish-yellow nodules. The most common histologic type is diffuse large B-cell lymphoma, followed by follicular B-cell lymphoma and Burkitt's lymphoma.[3]

Location

The most common site is the right atrium, although all chambers may be involved.[9]

Arrhythmias

Cardiac lymphoma is associated with atrial fibrillation.[3] Occasionally, it can cause AV blocks as a result of the involvement of the AV node.[31]

Diagnosis

On echocardiography, the tumor appears as a homogeneous, infiltrating mass leading to "wall thickening" and restrictive hemodynamics,

or as a nodular mass intruding into the heart chamber, usually the right heart chambers and especially the right atrium. Transesophageal echocardiography is superior to transthoracic echocardiography for imaging as it delineates the tumor better. Histologic diagnosis can be made based on cytology testing of pericardial fluid or by transvenous biopsy under echocardiographic guidance and helps in directing therapy.[31]

Treatment

Prognosis of primary lymphomas is better if patients are suitable for chemotherapy, although the median survival time after the initial treatment is 7 months. Radiation therapy is less effective, and surgical resection of the entire tumor is extremely difficult.[31]

6 | SECONDARY CARDIAC TUMORS

The incidence of cardiac involvement by systemic neoplastic disease ranges from 2% to 21%. Although not specific, atrial tachycardia, atrial fibrillation, conduction defect, and low voltage complexes on ECG in a patient with underlying malignancy should alert the clinician to the presence of cardiac metastases.[32] Metastatic cardiac tumors are incurable with dismal prognosis, and the therapy is mostly conservative and aimed at reducing the patient's discomfort.[8] Radiotherapy and chemotherapy, local or systemic, are used to control cardiac metastases along with antiarrhythmic therapy.

7 | CONCLUSIONS

Cardiac tumors are a rare but important cause of incessant arrhythmias and sudden death. It is important to identify cardiac tumors as a cause of arrhythmia because most of them are benign and amenable to surgical resection resulting in a cure with excellent prognosis. Implantable cardioverter defibrillator placement is not indicated after a curative resection of a primary cardiac tumor. Prognosis for secondary cardiac tumors is poor, and the treatment is palliative.

CONFLICT OF INTEREST

The author declares no Conflict of Interests for this article.

REFERENCES

1. Centofanti P, Di Rosa E, Deorsola L, et al. Primary cardiac tumors: early and late results of surgical treatment in 91 patients. Ann Thorac Surg. 1999;68:1236–41.
2. Miyake CY, Del Nido PJ, Alexander ME, et al. Cardiac tumors and associated arrhythmias in pediatric patients, with observations on surgical therapy for ventricular tachycardia. J Am Coll Cardiol. 2011;58:1903–9.
3. Butany J, Nair V, Naseemuddin A, Nair GM, Catton C, Yau T. Cardiac tumours: diagnosis and management. Lancet Oncol. 2005;6:219–28.
4. Cina SJ, Smialek JE, Burke AP, Virmani R, Hutchins GM. Primary cardiac tumors causing sudden death: a review of the literature. Am J Forensic Med Pathol. 1996;17:271–81.
5. Garson A, Smith RT, Moak JP, et al. Incessant ventricular tachycardia in infants: myocardial hamartomas and surgical cure. J Am Coll Cardiol. 1987;10:619–26.
6. Reynen K. Cardiac myxomas. N Engl J Med. 1995;333:1610–7.
7. McAllister HJ, Fenoglio JJ. Tumors of the cardiovascular system. Atlas of tumor pathology. 2nd series. Fascicle 15. Washington: Armed Forces Institute of Pathology, 1978, p. 1–20.
8. Mukai K, Shinkai T, Tominaga K, Shimosato Y. The incidence of secondary tumors of the heart and pericardium: a 10-year study. Jpn J Clin Oncol. 1988;18:195–201.
9. Burke A, Tavora F. The 2015 WHO classification of tumors of the heart and pericardium. J Thorac Oncol. 2016;11:441–52.
10. Kusano KF, Ohe T. Cardiac tumors that cause arrhythmias. Card Electrophysiol Rev. 2002;6:174–7.
11. Vander Salm TJ. Unusual primary tumors of the heart. Semin Thorac Cardiovasc Surg. 2000;12:89–100.
12. Burke A, Jeudy J, Virmani R. Cardiac tumours: an update. Heart. 2008;94:117–23.
13. Wacker-Gussmann A, Strasburger JF, Cuneo BF, Wiggins DL, Gotteiner NL, Wakai RT. Fetal arrhythmias associated with cardiac rhabdomyomas. Hear Rhythm. 2014;11:677–83.
14. Lessick J, Schwartz Y, Lorber A. Neonatal advanced heart block due to cardiac tumor. Pediatr Cardiol. 1998;19:263–5.
15. Mankad R, Herrmann J. Cardiac tumors: echo assessment. Echo Res Pract. 2016;3:R65–77.
16. Sparrow PJ, Kurian JB, Jones TR, Sivananthan MU. MR imaging of cardiac tumors. Radiographics. 2005;25:1255–76.
17. Lee KJ, Shin JH, Choi JH, et al. A case of arteriovenous type cardiac hemangioma. Korean J Intern Med. 1998;13:123–6.
18. Wang Y, Liu S, Yang J, Gu T, Zhang L. Cardiac hemangioma caused ventricular arrhythmia: a rare case and literature review. J Electrocardiol. 2017;50:667–70.
19. Abu-Omar Y, Mezue K, Ali A, Kneeshaw JD, Goddard M, Large SR. Intractable ventricular tachycardia secondary to cardiac hemangioma. Ann Thorac Surg. 2010;90:1347–9.
20. Luna A, Ribes R, Caro P, Vida J, Erasmus JJ. Evaluation of cardiac tumors with magnetic resonance imaging. Eur Radiol. 2005;15:1446–55.
21. Becker AE. Primary heart tumors in the pediatric age group: a review of salient pathologic features relevant for clinicians. Pediatr Cardiol. 2000;21:317–23.
22. Bauer MF, Aebert H, Zurbr?gg H, R?schoff J, Birnbaum DE. Torsades de pointes arrhythmia in a patient with left ventricular myxoma. Chest. 1994;105:1876–8.
23. Badui E, Cruz H, Almazan A, Enciso R, Soberanis N, Garcia R. Ventricular tachycardia as a first manifestation of right ventricular myxoma a case presentation. Angiology. 1991;42:1002–5.
24. Araoz PA, Mulvagh SL, Tazelaar HD, Julsrud PR, Breen JF. CT and MR imaging of benign primary cardiac neoplasms with echocardiographic correlation. Radiographics. 2000;20:1303–19.
25. Hananouchi GI, Goff WB. Cardiac lipoma: six-year follow-up with MRI characteristics, and a review of the literature. Magn Reson Imaging. 1990;8:825–8.
26. Shenthar J, Sharma R, Rai MK, Simha P. Infiltrating cardiac lipoma presenting as ventricular tachycardia in a young adult. Indian Heart J. 2015;67:359–61.
27. Friedberg MK, Chang IL, Silverman NH, Ramamoorthy C, Chan FP. Near sudden death from cardiac lipoma in an adolescent. Circulation. 2006;113:778–80.
28. Shirani J, Roberts WC. Clinical, electrocardiographic and morphologic features of massive fatty deposites ("lipomatous hypertrophy") in the atrial septum. J Am Coll Cardiol. 1993;22:226–38.

29. Heyer CM. Lipomatous hypertrophy of the interatrial septum: a prospective study of incidence, imaging findings, and clinical symptoms. CHEST J. 2003;124:2068.
30. Fyke FE 3rd, Tajik AJ, Edwards WD, Seward JB. Diagnosis of lipomatous hypertrophy of the atrial septum by two-dimensional echocardiography. J Am Coll Cardiol. 1983;1:1352–7.
31. Miguel CE, Bestetti RB. Primary cardiac lymphoma. Int J Cardiol. 2011;149:358–63.
32. Cates CU, Virmani R, Vaughn WK, Robertson RM. Electrocardiographic markers of cardiac metastasis. Am Heart J. 1986;112:1297–303.

How to cite this article: Shenthar J. Clinical presentations, diagnosis, and management of arrhythmias associated with cardiac tumors. *J Arrhythmia*. 2018;34:384–393. https://doi.org/10.1002/joa3.12030