Masses in right side of the heart: spectrum of imaging findings

Silvia Pradella¹, Giulia Grazzini¹, Mayla Letteriello¹, Cristian De Amicis¹, Roberta Grassi², Nicola Maggialetti³, Mattia Carbone⁴, Pierpaolo Palumbo⁵, Marina Carotti⁶,⁷, Ernesto Di Cesare⁸, Andrea Giovagnoni⁶,⁷, Diletta Cozzi¹, Vittorio Miele¹

¹Department of Radiology, Careggi University Hospital, Florence, Italy; ²Department of Precision Medicine, University of Campania “Luigi Vanvitelli”, Naples, Italy; ³Department of Medicine and Health Sciences “V. Tiberio”, University of Molise, Campobasso, Italy; ⁴Department of Radiology, S. Giovanni and Ruggi D’Aragona Hospital, Salerno, Italy; ⁵Department of Biotechnology and Applied Clinical Sciences, University of L’Aquila, L’Aquila, Italy; ⁶Department of Clinical, Special and Dental Sciences, University Politecnica delle Marche, Ancona, AN, Italy; ⁷University Hospital “Umberto I-Lancisi-Salesi”, Department of Radiology, Ancona, Italy; ⁸Department of Life, Health & Environmental Sciences, University of L’Aquila, L’Aquila, Italy

Summary. Primary heart tumors are rare, benign tumors represent the majority of these. If a cardiac mass is found, the probability that it is a metastasis or a so-called “pseudo-mass” is extremely higher than a primary tumor. The detection of a heart mass during a transthoracic echocardiography (TE) is often unexpected. The TE assessment can be difficult, particularly if the mass is located at the level of the right chambers. Cardiac Computed Tomography (CCT) can be useful in anatomical evaluation and Cardiac Magnetic Resonance (CMR) for masses characterization as well. We provide an overview of right cardiac masses and their imaging futures. (www.actabiomedica.it)

Keywords: Cardiac masses, right heart, tumors, MRI, CT
of contrast material or radiation exposure (30). However, echocardiography provides limited assessment of soft-tissue characteristics and extracardiac structures, it may be limited by poor acoustic windows, particularly for right chambers evaluation mostly in obese patients and the uncooperative ones.

Different imaging modalities are available for anatomical evaluation and characterization of tissues and masses in various district, including the heart (31-50). Multimodality imaging such as cardiac MR prevents misdiagnosis which often leads to unnecessary cardiac surgery (51). Cardiac CT (CCT), CMR, and 18F-FDG PET/CT work synergistically with echocardiography. Non-invasive imaging can distinguish tumor from “tumor like” mass and highlight typical characteristics of benign tumors differentiating them from malignant ones (8). CMR is fundamental to differentiate malignant from benign tumors through the use of multiparametric sequences (52). CCT has a limited role in tissue characterization compared to the CMR imaging; but both can be used synergistically with echocardiography to detect the mass, define its exact location and its anatomical relationships with adjacent structures (53). Appropriate Use Criteria for CMR and CCT provide specific guidance on the approach to cardiac masses. Since CMR does not require the use of ionizing radiation, it is the modality of choice particularly for pediatric patients, along with echocardiography(4). CMR quality images is dependent on patient cooperation. Additionally, CMR is specifically contraindicated in patients with claustrophobia and implanted unsafe magnetic devices. Also, CMR may be inadequate for evaluating small mobile masses (e.g., papillary fibroelastoma or valvular vegetations) due to limitations in spatial resolution. CCT provides an optimal anatomical evaluation and, in the presence of ECG-gating, a detailed assessment of the coronary arteries, fundamental prior to surgery. ECG gating, however, it is used to reduce motion artifacts, which can preclude detecting small lesions and cause blurring of the margins of larger lesions. Prospective ECG-gating is preferred because it allows lesion mobility through the reconstruction of cine images. To obtain an appropriate opacification in the right heart chambers (not so dense as to create streak artifacts) is indicated an intravenous infusion of iodinated contrast medium (for adults about 60-70 mL at 5 mL/s) followed by a 50%/50% contrast: saline flush. A delayed phase (obtained 2–3 min later without additional contrast injection) can be performed to help with tissue characterization. Considering that the radiation dose is very low with the latest CT generation, the CT can be a valid alternative to CMR (53, 54). Transesophageal echocardiography (TEE), like threedimensional studies, can be a useful tool in addition to TE to clarify cardiac mass lesions characteristics in selected patients (8).

**Right sided cardiac masses: lesion characteristics and imaging approach**

In clinical practice, whenever a cardiac mass is detected on echocardiography, a reasonable approach is to focus on the location first, and then on the imaging characteristics (Table 1). The clinical context and symptom presentation must guide us into getting the correct diagnosis. Embolic phenomena into the pulmonary circulation are an example of right sided lesions symptom onset. A reduction of cardiac output can result from an intracavity obstruction or valvular dysfunction caused by a tumor hemodynamically expressive. Generally, features that suggest a malignant lesion include myocardium and pericardium invasion resulting in arrhythmias, heart failure and pericardial effusions. Features that suggest a benign lesion include a well-defined and single mass that involves a single cardiac chamber (more frequent left than right); small size (<5 cm) and smooth margin; the presence of a narrow transition zone or pedunculated appearance; absent or minimal enhancement; absence of local invasion, metastasis and pericardial effusion; rare calcification (except for small foci in fibroma, myxoma, or teratoma) (Table 2) (6, 55).

**Primary cardiac tumors**

**Benign Cardiac tumors**

- **Myxoma.** Approximately, myxomas have an incidence of 0.0017% in the general population and they count 25–50% of all primary cardiac tumors. They are most common from the third to sixth decade of life. Myxoma can arise in the LA (75%), but they may arise
### Table 1. Right sided cardiac most common masses- main characteristics

| Cardiac masses | Lesion category | Age and sex | Incidence | Common location | Imaging typical features |
|----------------|-----------------|-------------|-----------|-----------------|-------------------------|
| Myxoma         | Benign tumor    | Adult, female-to-male ratio 2.7:1 | Most common primary cardiac tumor (50% of benign tumors) | Atria (95%): left (75%) right (20%) | Spherical, mobile, hyperintense on T2 w CMR images, 10 % calcified |
| Papillary fibroelastoma | Benign tumor | Adult, female-to-male ratio 1:1 | Third in the prevalence of benign cardiac tumors | Predominantly from the aortic or mitral valve (usually tricuspid valve) | Pedunculated usually mobile, solitary, small (10 mm), smooth, hyperintense on T2 w CMR images |
| Lipoma         | Benign tumor    | Middle-aged and older adults, female-to-male ratio 1:1 | About 8% of primary cardiac tumors approximately 14% of benign cardiac masses | Any chamber, intra-myocardial or intracavitary | Encapsulated, well-circumscribed, may be mobile, signal dropout on STIR CMR sequences. Low-attenuation on CT |
| Rhabdomyoma    | Benign tumor    | Children  | The most common benign pediatric cardiac tumor | Left ventricle and septum (70%), right ventricle and atrial wall (30%) | Single or multiple well circumscribed, hyperintense on T2w CMR images, no or minimal enhancement |
| Angiosarcoma    | Malignant tumor | Adult, female-to-male ratio 1:2-3 | Rare, 0.0001% in autopsy series | Right atrium | Broad base, irregular, heterogeneous, infiltrative, pericardial effusion, metastatic. Heterogeneous signal on CMR: isointense on T1w and hyperintense on T2w. Heterogenous CE with a “sun ray appearance” |
| Lymphoma       | Malignant tumor | Adult, median age 60 years old (range of 13–90 years old) | Secondary cardiac involvement by lymphoma 25% of patients, primary cardiac lymphoma 2% of cardiac primary tumors | Right atrium | Ill-defined, infiltrative (encasing adjacent structures), often pericardial effusion. On CMR: isointense on T1w and hyperintense on T2w. Homogenous CE |
| Metastases     | Malignant tumors | Adult, female-to-male ratio 1:1 | 9 % in patients with metastatic cancer. Intracavitary metastases are rare, making up 3% to 5% of cardiac metastases | Pericardial. Any one of the heart chambers (if intracavitary) | CMR: hypointense on T1w and hyperintense on T2w. Heterogenous CE |
| Right Intracardiac thrombus | Non-neoplastic | Any age and sex; depend on underlying cardiaco-pulmonary disease | Intracardiac thrombi are found in about 10% of cases of pulmonary thromboembolism (PTE). | Right atrium, right ventricle, or main pulmonary artery | Intracavitary and freely mobile, especially if recently formed thrombi. No CE in early contrast phases |
| Prominent crista terminalis | Non-neoplastic | Any age and sex | Occasional finding | Right atrium | A well-defined fibromuscular ridge on the posterolateral wall of the right atrium |

### Table 2. Suggestive lesion features

| Mass characteristics | Benign | Malignant |
|----------------------|--------|-----------|
| Location             | Left > right | Right > left |
| Dimension            | Small (<5 cm), single mass | Large (>5 cm), several masses |
| Calcification (if present) | Small | Large |
| Shape                | Well defined margins, pedunculate | Irregular margins, broad base, signs of infiltration |
| Contrast Enhancement | Usually absent | Weak to intense |
Masses in right side of the heart: spectrum of imaging findings

in other sites, such as the right side of the heart (5-20%), especially the RA (56). The sizes of these tumors vary from 1 to 15 cm and, usually, they appear as well defined, smooth and lobular mass, pedunculated.

On CMR images, myxomas have a typical heterogeneous appearance with variable iso- or hypointensity on T1-weighted sequences and hyperintensity on T2-weighted sequences due to their water content (Fig.1). Their heterogeneous appearance is due to the presence of intrallesional hemorrhagic foci, cysts, necrosis, fibrosis, and calcification. Myxomas show heterogeneous enhancement mostly hypointense on first-pass perfusion sequences, with areas iso- or hyperintense on late gadolinium enhancement (LGE) sequences (4, 30).

On CT images myxomas appear as a lobular mass with low attenuation (usually like water attenuation values) with intrallesional calcification, especially in myxoma localized in the RA. After the administration of contrast medium, they show heterogeneous contrast enhancement (CE) (6, 57).

-Papillary fibroelastoma. Papillary fibroelastoma (PF) has an incidence of up to 0.33 % in autopsy series and it is the third most common primary benign cardiac tumor (58). PFs are more frequent among the 4th and 8th decades of life. PFs are most commonly on the surface of the valves (80%) and consist of connective tissue (58). All heart valves can be affected, though the aortic valve is the most frequently involved, followed by the mitral valve. Gowda et al. (58) reported in a review of 725 cases of PFs that tricuspid valve was involved in 11% of cases, and pulmonary valve in 7%; while in the 4% of the cases PFs arise from endocardial surface of right atrium, right ventricle, right atrial appendage and Eustachian valve. Most of the patients are asymptomatic and PFs are diagnosed accidentally; however, they can be associated with valve dysfunction, embolization from attached thrombi and fragmentation (59). They are usually small (average diameter of 10 mm) and they appear as pedunculated or mobile masses (59). PFs are not always easily visible on

Figure 1. Right atrium myxoma- 70-year-old female. Rounded and well-defined mass (diameter about 22 mm) mobile, isointense to myocardial tissue on TrueF cine sequence (black arrow) (A), hypointense on first-pass perfusion sequences (white arrowhead) (B) and isointense to myocardial on LGE (C).
CMR due to the small size. On CMR cine-sequences they appear as small mobile and homogeneous valvular mass surrounding turbulent flow, with isointense T1 and hyperintense T2 signal intensity. Fat-saturation sequences are useful to differentiate fibroelastomas from lipomas, because the first one has no signal loss dropout. In cardiac CT, they appear small, hypodense attached through a thin stalk to valve surface (6).

-Lipoma. Lipomas represent about 8% of primary cardiac tumors and approximately 14% of benign cardiac masses, with an incidence of 0.2 and 0.4% reported in autopsy studies. Lipomas can occur in all age groups, but they’re most likely to be found in the fifth and sixth decades of life (60). Lipomas are encapsulated and well-defined tumors containing neoplastic adipocytes (6). Typically, lipomas are localized in the RA and the left ventricle (LV) (60). In most cases, cardiac lipomas are discovered accidentally and the patients are asymptomatic. Rarely, very large lipomas can lead to symptomatic obstruction of the tricuspid valve or vena cava resulting in heart failure. They can be multiple in patients with tuberous sclerosis (61). On CMR they appear slightly hyperintense on T2-weighted, homogeneous hyperintense on T1-weighted, with loss of signal on fat suppression sequences, and with no CE (30). On CT imaging they appear with a homogeneous fat attenuation (density<-50 Hounsfield units), without CE (6).

-Rhabdomyoma. Rhabdomyoma is the most common benign pediatric cardiac tumor, frequently associated with tuberous sclerosis. These tumors involve children from fetal age to early infancy and tend to regress spontaneously (56). They are multiple in 90% of cases and most commonly localized in the LV and ventricular septum, although up to 30% of cases the atrial wall or RV are involved (62). These tumors may present clinically with arrhythmia and heart failure. Usually, echocardiography is adequate for making the diagnosis, but CMR can be useful in atypical presentations or for surgical planning (4). On imaging, they appear as single or multiple well-circumscribed, intramural or intracavitary masses. On CMR images, rhabdomyomas are homogeneous on all sequences, isointense to normal myocardium on T1-weighted images and hyperintense on T2-weighted images, and they show no or minimal enhancement on first-pass perfusion imaging and iso-intensity on LGE images (4). CCT is rarely performed because the affected population is mainly pediatric.

-Fibroma. Fibroma is the second most common type of pediatric cardiac tumor (63). It occurs rarely in adolescents or adults (about 15%) (56). Cardiac fibromas typically arise in the LV (63). Although, cases of fibromas located in the RV (30%) and RA (10%) have been reported (64). The average diameter of this tumor is 5 cm and the clinical onset depends upon their location and size. On CMR imaging fibromas are slightly hypointense on T2-weighted images and isointense on T1-weighted images relative to muscle, due to their dense and fibrous nature. They have well-defined borders; little or no CE during the early phases, hyper-enhancement on LGE and high extracellular volume (ECV) values (63, 64). On CT, fibroma appears as a homogeneous mass, with low attenuation and no or minimal enhancement. The characteristic presence of central calcification (patchy hypointense foci within the lesion) is useful to differentiate it from rhabdomyoma (6).

-Hemangioma. Hemangioma is a rare benign vascular tumor (2.8% of primary cardiac tumors) that can arise from any cardiac chamber, with a predilection of RA and interventricular septum. In a review of 200 cases of hemangiomas, Weidong Li (65) reported that in the 44.1% of cases the right heart was involved (including RA, RV, tricuspid valve, and pulmonary valve). The average age of patients was 43 years old; however, pre-natal cases are also described with a range from the 20th gestational week up to 86 years (65). Hemangioma can be symptomatic in case of bleeding (56). On CMR images, hemangiomas appear heterogeneous with intermediate signal on T1 images and inhomogeneous hyperintense T2 images because of the presence of calcification and fibrous septa; after administration of gadolinium the mass shows intense enhancement due to its vascular structures. In the same way, on CT images hemangioma appears heterogeneous with intense enhancement (65).

Malignant cardiac tumors

-Sarcomas. Sarcomas are mesenchymal tumors and they are the most common cardiac primary malig-
nant neoplasms (3, 56). Usually, males are affected more often than females with a ratio of 2–3/1. The patients younger than 65 years old are the most affected (66).

Any type of sarcoma can affect the heart but angiosarcoma is the most frequent in the right chambers, especially in the RA (80% of cardiac angiosarcomas); while leiomyosarcoma, osteosarcoma and malignant fibrous histiocytoma are the most common in the left chambers. Sarcomas are generally large and they can frequently infiltrate adjacent structures (56). Hemorrhagic pericardial effusion is frequently present. Dyspnea is the most common presenting symptom; however, the patient may also present chest pain, embolic phenomena, peripheral edema, arrhythmias, syncope and sudden death (1). At the time of diagnosis patients can have metastases, most commonly to lungs, lymph nodes, bone and liver (56). CT shows the presence of large lesion, typically with a broad-based attachment and heterogenous CE because are present hemorrhagic and necrosis areas (6, 57).

On CMR T1-weighted images, the mass appears predominantly isointense to myocardium, eventually with areas of high signal due to the presence of intraleisional hemorrhage. On T2-weighted images, especially angiosarcoma shows a heterogeneous predominantly hyperintense appearance (Fig. 2). On LGE sequences the tumor has a “sunrise appearance” (peripheral enhancement and central areas of necrosis) (30, 67).

-Lymphoma. Cardiac primary lymphoma is generally a non-Hodgkin type. Secondary cardiac involvement by lymphoma is about 25% of patients with a disseminated lymphoma, while primary cardiac lymphoma is 2% of cardiac primary tumors. The age range of presentation is between 13–90 years old (56). Most commonly lymphomas arise from the right heart chambers, particularly the RA, followed by the RV

Figure 2. Right atrium angiosarcoma treated with radiotherapy- 57-year-old female. Large with a broad-based mass into the right atrium associated to thickening of the pericardium (red arrow), predominantly isointense to myocardium on T1-weighted image (A). On T2-weighted image, SPIR, the mass shows a typical and high signal hyperintensity (star) (B); heterogenous appearance on balance cine sequences (C).
(56). Often it is associated with pericardium effusion and invasion of the pericardium is frequent. On CT images lymphoma appears or as multiple solid masses attached to the myocardium, or, more commonly, as myocardial or epicardial infiltrative large mass, hypodense or isodense related to the myocardium; with a slight CE. A peculiar characteristic of lymphoma is its diffusion along the surface of the adjacent structures enclosing them (68). On CMR usually, lymphomas are homogeneous relatively hypointense on T1-weighted images and hyperintense on T2-weighted images. CE may be homogeneous or heterogeneous, but not so intense as other malignant tumors (30). The absence of necrosis or hemorrhage areas is useful to distinguish cardiac lymphoma from angiosarcoma.

-Metastasis. Cardiac metastases are more frequent than primary cardiac malignancy(30). Malignant tumors can metastasize to the heart through the direct extension of adjacent organs (lung, esophagus), or through blood vessels dissemination (melanoma) or venous extension into the right atrium within the inferior vena cava (renal cell carcinoma and hepatocellular carcinoma) and via mediastinal lymphatics. The most frequent location of metastasis is the pericardium (64-69%), followed by epicardium (25-34%) and myocardium (30%). Intracavitary metastases are rare, making up 3% to 5% of cardiac metastases (Fig. 3) (69). Usually, the imaging features of metastatic disease are not specific, but generally, they have heterogeneous CE, low signal intensity on CMR T1-weighted images and high signal intensity on T2-weighted images. The only exception is reserved for melanoma metastases which appear hyperintense on T1 because of the presence of melanin pigment and also hemorrhagic lesions can show hyperintense areas on T1-weighted images due to the blood degradation products. (30, 67).

Cardiac pseudo-masses

-Thrombosis. Thrombi are the most common intracavitary masses. Thrombus can occur in any of the

![Figure 3](image-url)

Figure 3. Right ventriculus chordoma metastasis -69-year-old male, with a history of sacral chordoma surgically removed about 10 years before. On TE accidentally discovered a mass in the right ventricular outflow tract (RVOT) (black arrow) (A). CMR shows a solid and rounded mass with regular edges, about 3 cm, intracavitary, slightly inhomogeneous on TruFi cine sequence (white arrow) (B); slightly hyperintense to myocardium on T2- STIR sequence (white arrow) (C). The mass shows different values on T1 map compared to normal adjacent myocardium (black arrow) (D) and progressive CE (white arrow) (E).
Masses in right side of the heart: spectrum of imaging findings

Masses in right side of the heart but are typically found in the LA in patients with atrial fibrillation. However, they develop in the region where the flow is slowed or around foreign bodies (for example central venous catheter tip) ([Fig. 4](#fig4)). Thrombus is easily detected on CCT image, especially on delayed imaging, as a low-attenuation mass, without CE. Chronic thrombi may present peripheral enhancement because of the presence of a fibrous pseudo-capsule and may develop spotty calcifications. On CMR first pass enhancement images and LGE thrombus show no CE (30, 55).

Pseudo-masses. Pseudo masses are normal structures misinterpreted as pathological findings. The orifice of the inferior vena cava (Eustachian valve) can simulate a mass. Into RA the “crista terminalis” or hypertrophic or accessory trabeculae (into RA and RV) may appear as a thrombus or as a mass. Also, lipomatous hypertrophy of the interatrial septum (LHIS) can simulate a tumor (70). LHIS is indistinguishable from lipoma except that the former occurs in the atrial septum with a typical distribution (generally sparing the fossa ovalis). They are asymptomatic and do not require resection (71, 72).

**Conflict of interest:** Authors declare that they have no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

### References

1. Paraskevaidis IA, Michalakeas CA, Papadopoulos CH, Anastasiou-Nana M. Cardiac tumors. ISRN Oncol 2011; 2011: 208929.
2. Robertson R. Primary cardiac tumours; surgical treatment. American journal of surgery 1957; 94: 183-93.
3. Basso C, Rizzo S, Valente M, Thiene G. Cardiac masses and tumours. Heart (British Cardiac Society) 2016; 102: 1230-45.
4. Ghadimi Mahani M, Lu JC, Rigsby CK, Krishnamurthy R, Dorfman AL, Agarwal PP. MRI of pediatric cardiac masses. AJR. American journal of roentgenology 2014; 202: 971-81.
5. Bovet P, Paccaud F. Body-mass index and mortality. Lancet (London, England) 2009; 374: 113; author reply 114.
6. Kassop D, Donovan MS, Cheezum MK, et al. Cardiac Masses on Cardiac CT: A Review. Current cardiovascular imaging reports 2014; 7: 9281.
7. Lichtenberger JP, 3rd, Reynolds DA, Keung J, Keung E, Carter BW. Metastasis to the Heart: A Radiologic Approach to Diagnosis With Pathologic Correlation. AJR. American journal of roentgenology 2016; 207: 764-772.
8. Susic L, Baraban V, Vincelj J, et al. Dilemma in clinical diagnosis of right ventricular masses. Journal of clinical ultrasound : JCU 2017; 45: 362-369.
9. Obeid AI, al Mudamgha A, Smulyan H. Diagnosis of right atrial mass lesions by transesophageal and transthoracic echocardiography. Chest 1993; 103: 1447-51.
10. Agliata G, Schicchi N, Agostini A, et al. Radiation exposure related to cardiovascular CT examination: comparison between conventional 64-MDCT and third-generation
11. Rahouma M, Arisha MJ, Elmously A, et al. Cardiac tumors prevalence and mortality: A systematic review and meta-analysis. Int J Surg. 2020;76:178-189.

12. Agostini A, Kircher MF, Do R, et al. Magnetic Resonance Imaging of the Liver (Including Biliary Contrast Agents) Part 1: Technical Considerations and Contrast Materials. Seminars in roentgenology 2016; 51: 308-316.

13. Malik SB, Chen N, Parker RA 3rd, Hsu JY. Transthoracic Echocardiography: Pitfalls and Limitations as Delineated at Cardiac CT and MR Imaging. Radiographics. 2017;37:383-406.

14. Agostini A, Mari A, Lanza C, et al. Trends in radiation dose and image quality for pediatric patients with a multidetector CT and a third-generation dual-source dual-energy CT. La Radiologia medica 2019; 124: 745-752.

15. Díaz Angulo C, Méndez Díaz C, Rodríguez García E, Soler Fernández R, Rois Siso A, Marini Díaz M. Imaging findings in cardiac masses (Part I): study protocol and benign tumors. Radiologia. 2015;57:480-488.

16. Zhu D, Yin S, Cheng W, et al. Cardiac MRI-based multimodality imaging in clinical decision-making: Preliminary assessment of a management algorithm for patients with suspected cardiac mass. Int J Cardiol. 2016;203:474-481.

17. Rajiah P, MacNamara J, Chaturvedi A, Ashwath R, Fulton NL, Goerne H. Bands in the Heart: Multimodality Imaging assessment of a management algorithm for patients with suspected cardiac mass. Int J Cardiol. 2016;203:474-481.

18. Maleszewski JJ, Anavekar NS, Moynihan TJ, Klarich KW. Pathology, imaging, and treatment of cardiac tumours. Nat Rev Cardiol. 2017;14:536-549.

19. Tower-Rader A, Kwon D. Pericardial Masses, Cysts and Diverticula: A Comprehensive Review Using Multimodality Imaging of the Liver (Including Biliary Contrast Agents) Part 1: Technical Considerations and Contrast Materials. Seminars in roentgenology 2016; 51: 308-316.

20. Zoccali C, Rossi B, Zoccali G, et al. A new technique for biopsy of soft tissue neoplasms: a preliminary experience using MRI to evaluate bleeding. Minerva medica 2015; 106: 117-20.

21. Hong YJ, Hur J, Han K, et al. Quantitative Analysis of a Whole Cardiac Mass Using Dual-Energy Computed Tomography: Comparison with Conventional Computed Tomography and Magnetic Resonance Imaging. Sci Rep. 2018;8:15334.

22. Schiattarella GG, Cerulo G, De Pasquale V, et al. The Murine Model of Mucopolysaccharidosis IIIB Develops Cardiopathies over Time Leading to Heart Failure. PloS one 2015; 10: e0131662.

23. Tumma R, Dong W, Wang J, Litt H, Han Y. Evaluation of cardiac masses by CMR-strengths and pitfalls: a tertiary center experience. Int J Cardiovasc Imaging. 2016;32:913-920.

24. Ma G, Wang D, He Y, Zhang R, Zhou Y, Ying K. Pulmonary embolism as the initial manifestation of right atrial myxoma: A case report and review of the literature. Medicine (Baltimore). 2019;98:e18386.
Masses in right side of the heart: spectrum of imaging findings

42. Furlow B. Computed Tomography of Cardiac Malignancies. Radiol Technol. 2016;87:529CT-45CT.
43. Abrams HL. History of cardiac radiology. AJR Am J Roentgenol. 1996;167(2):431-8
44. Colin GC, Gerber BL, Amzulescu M, Bogaert J. Cardiac myxoma: a contemporary multimodality imaging review. Int J Cardiovasc Imaging. 2018;34:1789-1808.
45. Quarta G, Aquaro GD, Pedrotti P, et al. Cardiovascular magnetic resonance imaging in hypertrophic cardiomyopathy: the importance of clinical context. European heart journal cardiovascular Imaging 2018; 19: 601-610.
46. Wu CM, Bergquist PJ, Srichai MB. Multimodality Imaging in the Evaluation of Intracardiac Masses. Curr Treat Options Cardiovasc Med. 2019;21:55.
47. Ruscitti P, Cipriani F, Masedu F, et al. Increased Cardiovascular Events and Subclinical Atherosclerosis in Rheumatoid Arthritis Patients: 1 Year Prospective Single Centre Study. PloS one 2017; 12: e0170108.
48. Patel R, Lim RP, Saric M, et al. Diagnostic Performance of Cardiac Magnetic Resonance Imaging and Echocardiography in Evaluation of Cardiac and Paracardiac Masses. Am J Cardiol. 2016;117:135-140.
49. Di Cesare E, Battisti S, Di Sibio A, et al. Early assessment of sub-clinical cardiac involvement in systemic sclerosis (SSc) using delayed enhancement cardiac magnetic resonance (CE-MRI). European journal of radiology 2013; 82: e268-73.
50. Barone-Rochette G, Jankowski A, Rodiere M. Cardiac magnetic resonance imaging and cardiac computed tomography in clinical practice. Rev Med Interne. 2014;35(11):742-51
51. Glockner JF. Magnetic Resonance Imaging and Computed Tomography of Cardiac Masses and Pseudomasses in the Atrioventricular Groove. Canadian Association of Radiologists journal = Journal l’Association canadienne des radiologistes 2018; 69: 78-91.
52. Mousavi N, Cheezum MK, Aghayev A, et al. Assessment of Cardiac Masses by Cardiac Magnetic Resonance Imaging: Histological Correlation and Clinical Outcomes. Journal of the American Heart Association 2019; 8: e007829.
53. Schicchi N, Fogante M, Esposto Pirani P, et al. Third-generation dual-source dual-energy CT in pediatric congenital heart disease patients: state-of-the-art. La Radiologia medica 2019; 124: 1238-1252.
54. Agostini A, Borgheresi A, Mari A, et al. Dual-energy CT: theoretical principles and clinical applications. La Radiologia medica 2019; 124: 1281-1295.
55. Hoey E, Ganeshan A, Nader K, Randhawa K, Watkin R. Cardiac neoplasms and pseudotumors: imaging findings on multidetector CT angiography. Diagnostic and Interventional radiology (Ankara, Turkey) 2012; 18: 67-77.
56. Grebenc ML, Rosado de Christenson ML, Burke AP, Green CE, Galvin JR. Primary cardiac and pericardial neoplasms: radiologic-pathologic correlation. Radiographics : a review publication of the Radiological Society of North America, Inc 2000; 20: 1073-103; quiz 1110-1, 1112.
57. Young PM, Foley TA, Araoz PA, Williamson EE. Computed Tomography Imaging of Cardiac Masses. Radiologic clinics of North America 2019; 57: 75-84.
58. Gowda RM, Khan IA, Nair CK, Mehta NJ, Vasavada BC, Sacchi TJ. Cardiac papillary fibroelastoma: a comprehensive analysis of 725 cases. American heart journal 2003; 146: 404-10.
59. Howard RA, Aldea GS, Shapira OM, Kasznica JM, Daviddoff R. Papillary fibroelastoma: increasing recognition of a surgical disease. The Annals of thoracic surgery 1999; 68: 1881-5.
60. D’Souza J, Shah R, Abbass A, Burt JR, Goud A, Dahagam C. Invasive Cardiac Lipoma: a case report and review of literature. BMC cardiovascular disorders 2017; 17: 28.
61. Malik SB, Kwan D, Shah AB, Hsu JY. The right atrium: gateway to the heart--anatomic and pathologic imaging findings. Radiographics : a review publication of the Radiological Society of North America, Inc 2015; 35: 14-31.
62. Kondo T, Niida Y, Mizuguchi M, Nagasaki Y, Ueno Y, Nishimura A. Autopsy case of right ventricular rhabdomyoma in tuberous sclerosis complex. Legal medicine (Tokyo, Japan) 2019; 36: 37-40.
63. Sargar KM, Sheybani EF, Shenoy A, Aranake-Chrisinger J, Khanna G. Pediatric Fibroblastic and Myofibroblastic Tumors: A Pictorial Review. Radiographics : a review publication of the Radiological Society of North America, Inc 2016; 36: 1195-214.
64. Gravina M, Casavecchia G, Totaro A, et al. Left ventricular fibroma: what cardiac magnetic resonance imaging may add? International journal of cardiology 2014; 176: e63-5.
65. Li W, Teng P, Xu H, Ma L, Ni Y. Cardiac Hemangioma: A Comprehensive Analysis of 200 Cases. The Annals of thoracic surgery 2015; 99: 2246-52.
66. Hamidi M, Moody JS, Weigel TL, Kozak KR. Primary cardiac sarcoma. The Annals of thoracic surgery 2010; 90: 176-81.
67. Hoey ET, Shahid M, Ganeshan A, Baijul S, Simpson H, Watkin RW. MRI assessment of cardiac tumours: part 2, spectrum of appearances of histologically malignant lesions and tumour mimics. Quantitative imaging in medicine and surgery 2014; 4: 489-97.
68. Jeudy J, Kirsch J, Tavora F, et al. From the radiologic pathology archives: cardiac lymphoma: radiologic-pathologic correlation. Radiographics : a review publication of the Radiological Society of North America, Inc 2012; 32: 1369-80.
69. Goldberg AD, Blankstein R, Padera RF. Tumors metastatic to the heart. Circulation 2013; 128: 1790-4.
70. Rangel-Hernandez MA, Aranda-Fraustro A, Melendez-Ramirez G, Espinola-Zavaleta N. Misdiagnosis for right atrial mass: a case report. European heart journal. Case reports 2018; 2: yty004.
71. Bielicki G, Lukaszewski M, Kosiorowska K, Jakubaszko J, Nowicki R, Jasinski M. Lipomatous hypertrophy of the atrial septum – a benign heart anomaly causing unexpected
surgical problems: a case report. BMC cardiovascular disorders 2018; 18: 152.

72. Carino D, Agostinelli A, Ricci M, Romano G, Nicolini F, Gherli T. A rare case of ging lipomatous hypertrophy of the atrial septum. Acta bio-medica : Atenei Parmensis 2018; 89: 114-116.

Received: 20 May 2020
Accepted: 10 June 2020
Correspondence:
Diletta Cozzi, MD
Department of Radiology, Careggi University Hospital
L.go G.A. Brambilla, 3 - 50134 Florence – Italy
E-mail: dilettacozzi@gmail.com