CT and MR imaging in cardiac masses evaluation.

Poster No.: C-0957
Congress: ECR 2015
Type: Educational Exhibit
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Keywords: Cardiac, Oncology, Cardiovascular system, CT, MR, Diagnostic procedure, Staging, Cancer
DOI: 10.1594/ecr2015/C-0957

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Learning objectives

The aim of this study is to demonstrate the usefulness, in clinical practise, of cardiac masses study through CT, MRI or both.
Background

Cardiac masses can be divided in benign and malignant ones. Primitive cardiac tumour prevalence is very low, less than 0.3% in the general population, and, in the majority of cases, are benign masses (about 75%, of which 50% are myxomas). Malignant tumours represent 25% of primitive lesions, of which 95% are sarcomas, while much more frequent are secondary neoplasm (1.2% of incidence). An important differential diagnosis for cardiac masses is with thrombi, that are frequent in patients with atrial fibrillation, thrombophilia, dilated cardiomyopathy with ventricular function reduction and myocardial infarction (in this cases an endocavitary thrombus can be found in 15% of cases).

Symptoms have frequently a late onset, when the mass has already reached significant dimensions and it is often discovered casually, when the patient undergoes a clinical examination for other reasons.

CT, MRI and integrated use of both are useful for characterization, anatomical relationship and vascularization of masses definition.
Findings and procedure details

We have reviewed our case series of patients that underwent diagnostic examinations for cardiac masses assessment over a six months period. All patients have been studied with a CT scan (Somatom Definition Flash, Siemens; Optima, GE) and almost all of them also underwent an MRI (Aera, Siemens; Achieva, Philips).

Our case series includes five patients with myxoma, one angiosarcoma, three thrombi, one vascular infiltration from renal cancer, one cardiac lymphoma, one left ventricular pseudoaneurysm and one atrial pseudo-mass (hypertrophic crista terminalis). A high degree of diagnostic certainty about the nature of the lesions was reached either based on clinical response to treatment (mass regression in case it was a thrombus) or histological examination.

**Myxoma**

Myxomas represent 50% of all primitive cardiac tumours and in 75% of cases it originates from the left atrium, typically at the level of the interatrial septum along the fossa ovalis margin. At CT they appear inhomogeneously hypodense and present dystrophic calcifications (due to the repeated bleedings) (Fig. 1 on page 7; Fig. 2 on page 7); if the mass is pedunculated, dynamic sequences can show its motility and the possible consequent prolapse through the mitral or tricuspid valve (Fig. 3 on page 8). In MRI this lesion is hypointense or isointense in T1w sequences, hyperintense in T2w sequences, with inhomogeneous contrast enhancement pattern (useful in the differential diagnosis with thrombi); there is no adipose tissue saturation in specific sequences and inversion time is less than 450s (Fig. 3 on page 8).

**Cardiac thrombi**

Due to their frequency (thrombi are a complication in 15% of acute myocardial infarction cases), cardiac thrombi represent an important differential diagnosis with neoplastic cardiac masses. Thrombi arise more frequently in the atrium, typically in the appendage (due to blood stasis); they are smaller than myxomas and present the same or slightly higher density, but are less frequently mobile and they don't present contrast enhancement (except for recently formed thrombi). MRI is a useful tool in case of difficult differential diagnosis with myxomas or when there is no volume reduction of the mass after adequate therapy; thrombi are isointense in T1w sequences, hypointense in T2w and show no contrast enhancement (except for an eventual peripheral rim); there is no suppression of adipose tissue signal and inversion time is higher than that of myxomas (around 700ms) (Fig. 4 on page 9).
Angiosarcoma

Angiosarcoma is a rare malignant neoplasm that, due to its aggressiveness and symptoms late onset, is often already metastatic (III or IV stadium) at the diagnosis. At MRI (Fig. 5 on page 10), this lesion shows inhomogeneous signal intensity in T1w and T2w sequences (sometimes can appear hyperintense in T1w sequences with fat suppression due to its methaemoglobin content in case of sub acute haemorrhage), with inhomogeneous contrast enhancement in post-contrast images; it frequently appears as a big sessile lesion with a broad base of attachment on the myocardium, has central necrosis and its invasion of more than one cardiac chamber is possible; a frequent complication of angiosarcoma is cardiac tamponade. At CT it appears like a hypodense irregular or nodular mass, with inhomogeneous contrast enhancement because of the presence of necrotic or haemorrhagic areas; the pericardium can show serous or haemorrhagic effusion (Fig. 6 on page 11). Both modalities allow a non-invasive follow up of the lesions during treatment (Fig. 7 on page 12).

Renal tumour

Clear cell cancer tropism for venous vessels can lead to the formation of a neoplastic thrombus that extends to the renal vena and, through the inferior vena cava, arrives into the right atrium; the neoplasm can sometimes pass through the tricuspid valve plane and reach even the right ventricle. Neoplastic thrombus can be differentiated from the benign one with contrast enhancement administration, both in CT and in MRI, adding this data to other informations such as location, morphology and the associated primitive neoplasm (Fig. 8 on page 13).

Primitive cardiac lymphoma

Primitive cardiac lymphoma is extremely rare (90 cases reported in the literature), with bad prognosis in the majority of cases (10% of survival rate at 9 and 12 month). This pathology is more frequent in immunocompromised patients. They are non-Hodgkin lymphomas and, in the majority of cases, are diffuse large B-cell lymphomas. They can arise from all the cardiac chambers, but the right atrium is the most frequent location. At MRI they appear as big nodular mass isointense in T1w sequences and iso or hyperintense in T2w sequences, with inhomogeneous contrast enhancement pattern; they can occasionally show a diffuse infiltrative pattern. At CT they present as a mass isodense to myocardium that shows contrast enhancement (Fig. 9 on page 14).

Crista terminalis hypertrophy
The crista terminalis is an anatomical structure constituted of fibro-muscular tissue, oriented vertically respect to the postero-lateral right atrial wall and extended between the right portion of the superior vena cava orifice to the right side of the inferior vena cava outlet. In some cases, it can be hypertrophic mimicking an endoluminal mass when it's accidentally discovered. A CT study (Fig. 10 on page 15), especially if integrated with MRI (Fig. 11 on page 16), is fundamental to differentiate this anatomical variant from a cardiac pathological process.
Fig. 1: F, 49 y/o with dyspnea and acute chest pain. Cardiac CT shows a left atrial mass (asterisk); this mass reaches the mitral valve plane (A, 3CH) and is characterized by heterogeneous contrast enhancement (A, 3CH). Histological examination confirmed the diagnosis of myxoma.

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Fig. 2: F, 35 y/o with asthenia and chest pain. Cardiac CT shows a voluminous polylobate left atrial mass (asterisk), which moves with the cardiac cycle and protrudes through the mitral valve (A, 2CH and 4CH). This mass is characterized by inhomogeneous contrast enhancement (A, 2CH and 4CH). Histological examination confirmed the diagnosis of myxoma.

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Fig. 3: F, 65 y/o; incidental finding of right atrial mass at echocardiogram. Axial T1w MR (A) and CT (B) images confirm the presence of an oval right atrial mass that partially prolapses in the right ventricle, as confirmed by cine-MRI sequences (C, D). Histological examination confirmed the diagnosis of myxoma.

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**Fig. 4:** F, 78 y/o with idiopathic dilated cardiomyopathy (EF = 33%). The images show a massive thrombus in the left ventricle apex, without contrast enhancement (A1-3CH, A2-4CH, A3-SA), as well demonstrated by late enhancement MR sequences (B1-3CH, B2-4CH, B3-SA).

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**Fig. 5:** F, 33 y/o with chest pain, dyspnea, and a finding of right atrial mass at echocardiogram. MRI shows an heterogeneous solid mass, located along the free wall of the right atrium and that extends from the atrial floor to the auricle. Post-contrast sequences (H early, I delayed) allow to distinguish two components: one, more peripheral, markedly hypointense (I, asterisk) and without enhancement because of the absence of vascularization (thrombosis) and the second one that shows marked contrast enhancement (solid component of the tumour).

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Fig. 6: The same patient as in Fig. 10 underwent a CT examination that confirms the presence of a bulky mass along the free wall of the right atrium. This mass appears diffusely inhomogeneous, with hypodense areas, compatible with necrotic-haemorrhagic tissue and presents multiple vascular channels within that communicate with the right atrial cavity. CT also allows to distinguish the thrombotic component of the tumour. Transjugular intracavitary biopsy and the subsequent histological examination confirmed the diagnosis of angiosarcoma.

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Fig. 7: Follow-up CT of the same patient after the first cycle of chemotherapy. The right atrial mass appears reduced in dimensions, more hypodense and less vascularized. Also the solid component appears decreased in dimensions and without contrast-enhancement in the periphery, because of partial resolution of the thrombotic component.

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Fig. 8: M, 81 y/o with recent right heart failure and echocardiographic diagnosis of right atrial mass. The CT examinations shows a massive solid right atrial mass, that occupies the cavity reaching the mitral valve plane, causing a stasis of the contrast medium in the right atrium (A1, A2). A CT examination of the abdomen shows a voluminous renal lesion associated with thrombosis of the renal vein, which occupies the inferior vena cava up to the right atrium (B, C, D, E).

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Fig. 9: M, 65 y/o with asthenia, fever and weight loss. An echocardiogram demonstrated the presence of a cardiac mass. MRI shows a homogeneous mass, isointense in T2-w sequences (D), that infiltrates the right atrium wall and protrudes into the ventricular cavity, as shown by cine sequences (A, C, E). Pericardial and pleural effusion are associated. The presence of a large axillary lymph-node (B) suggested the diagnosis of a lymphoproliferative lesion. Histological examination confirmed the diagnosis.

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**Fig. 10:** F, 71 y/o with diabetes mellitus, ipercholesterolemia and typical angina; echocardiogram demonstrated an ovoid hyperechoic right atrial mass. CT shows a prominent crista terminalis (B, C, green arrows) and lipomatous hypertrophy of the interatrial septum (A: arrows; B, D: red arrows).

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**Crista Terminalis Hypertrophy**

**Fig. 11:** The same patient as in Fig. 10 underwent an MRI examination which confirmed the diagnostic hypothesis of crista terminalis hypertrophy. Morphological sequences without (A, C) and with adipose tissue signal saturation (D) show lipomatous hypertrophy of the interatrial septum, with the exception of the fossa ovalis. Cine sequences (B, E) demonstrate a markedly hypointense peripheral rim caused by chemical shift (India ink sign, red arrow), that confirms the hypothesis of adipose infiltration of the crista terminalis.

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Conclusion

CT cardiac imaging can show the presence of calcifications, provides informations about the presence and kind of mass vascularization and, thanks to its optimal spatial resolution, defines its anatomical relationships and allows the evaluation of coronary arteries, a useful tool in preoperative planning. On the contrary MRI has more accuracy in cardiac masses tissue characterization thanks to morphological T1 and T2 weighted sequences, sequences with fat suppression and early and late post-contrast sequences, fundamental for the evaluation of the vascularization.

Both techniques allow to evaluate the alterations of cardiac function and the presence of pericardial effusion. Integrated CT/MRI imaging has shown to be indispensable in the clinical and diagnostic management of patients with cardiac mass.
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